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JOURNAL of PALEONTOLOGY

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DECEMBER 1930

DISTINCTIVE NEW SPECIES OF FORAMINIFERA FROM THE OLIGOCENE OF MISSISSIPPI

HENRY V. HOWE
Louisiana State University, Baton Rouge, Louisiana

ABSTRACT

This paper contains descriptions of the new genus *Mississippina* and seven new species of foraminifera from the Oligocene of Mississippi.

INTRODUCTION

In conducting the studies of a class of 21 students in micropaleontology during the past year, the writer has had the opportunity of checking the identifications of over 60,000 specimens of foraminifera from the Oligocene of Mississippi. The study was originally intended merely to give statistical data on the percentages of each species present in the various Oligocene formations (a portion of which study the writer is presenting in a separate paper), but it soon became apparent that many undescribed species were present. In this paper the writer will not attempt to describe all of the new species found, but merely a few of the more unusual forms. Holotypes are in the Collection of the Cushman Laboratory for Foraminferal Research, Sharon, Massachusetts.

DESCRIPTION OF SPECIES

FAMILY LAGENIDAE

GENUS FLABELLINA D'ORBIGNY, 1839

FLABELLINA VICKSBURGENSIS HOWE, N. SP.

Plate 27, figure 2

Test roughly diamond-shaped, much compressed, apertural end extended; coiled in early part of test, followed by a linear series of cham-

bers shaped as in *Frondicularia*. Surface strongly punctate; ornamentation consisting of irregular polygonal areas bounded by raised lines between raised sutures. Sutures in the early part of test slightly modified by the reticulate pattern, but transparent and with transmitted convergent light clearly showing the early coiled portion which is characteristic of the genus. Aperture terminal, radiate; the apertural face of the last chamber being flattened and smooth.

Maximum length observed 1.01 mm.; maximum width 0.63 mm Length of figured specimen 0.74 mm.; width 0.53 mm.

Holotype from the Byram marl at Byram, Mississippi (7 individuals); and from the Red Bluff clay at Hiwannee, Mississippi (2 individuals).

It is significant that this record extends the range of the genus *Flabellina* from the Cretaceous to the top of the Oligocene in the Gulf Coast.

Family VERNEULINIDAE

Genus GAUDRYINA d'Orbigny, 1839

GAUDRYINA YOUNGI Howe, n. sp.

Plate 27, figure 1a-b

Textularia (nearest to *siphonifera*) Howe, *1928*, Jour. Pal., Vol. 2, p. 174 (list).

Test elongate, tapering, greatest width near the apertural end, early portion triserial and tricarinate, later portion biserial and subquadrate; the angles distinct, the broader faces of the test flattened, the angles of each chamber marked by fistulose processes which are usually broken at the tip showing the hollow within. Sutures distinct and depressed. Wall finely arenaceous. Aperture an arched opening on the inner margin of the last formed chamber.

Length 0.65 mm.; breadth 0.22 mm.; thickness 0.125 mm.

Holotype from the Byram marl at Byram, Mississippi, collected by Mr. Karl E. Young. This species is fairly common in most outcrop faunas of the Mississippi Oligocene, being quite common in the Red Bluff at Hiwannee, Mississippi.

For a most interesting discussion of fistulose forms of *Gaudryina* see Cushman's paper No. 68, Contr. Cushman Lab. Foram. Research, Vol. 4, pt. 4, 1928, pp. 107-112, pl. 16. *Gaudryina youngi* is obviously an intermediate type in the general line of evolution from *Gaudryina stephensoni* Cushman of the Cretaceous Wolf City sand of Texas to the Recent *Gaudryina siphonifera* (H. B. Brady) of the Indian Ocean and South Pacific.

FAMILY BULIMINIDAE

GENUS LOXOSTOMA[1] EHRENBERG, 1854

LOXOSTOMA HIWANNEENSE HOWE, N. SP.

Plate 27, figure 7

Bolivina amygdalaeformis HOWE *1928*, (not H. B. Brady), Jour. Pal., Vol. 2, No. 3, p. 174 (list).

Test small, elongate, only slightly compressed, tending to become uniserial, sides nearly parallel, periphery rounded, chambers comparatively few. Sutures hidden by the surface ornamentation, consisting of numerous delicate irregularly anastomosing costae. Surface finely punctate. Aperture terminal or nearly so.

Length 0.40 mm.; breadth 0.33 mm.

Holotype from the Red Bluff clay at Hiwannee, Mississippi. The species is very abundant at this locality and the description is based on 76 individuals. It is similar in the pattern of its sculpture to *L. amygdalaeformis* var. *delicata* as pictured by Cushman from the Byram marl, but the anastomosing lines are much finer; the shape is very different, being much less compressed, the sides are nearly parallel instead of divergent; and it is a very much smaller form.

FAMILY ROTALIIDAE

GENUS MISSISSIPPINA HOWE, N. G.

Genoholotype: *Mississippina monsouri* HOWE, n. sp.

Test in early stages trochoid, later becoming almost planispiral, convex on the dorsal side, somewhat umbilicate on the ventral side, all whorls visible on the dorsal side and nearly all preceding whorls visible on ventral side. Sutures depressed. Wall calcareous, dense. Apertures of two sorts, one at the base of the last formed chamber at the periphery, the others elongate on both the dorsal and ventral margins in the neighborhood of the periphery and in the axis of coiling, in later growth usually partially filled with shell material.

This form is obviously related to *Epistomina* Terquem, but differs in the mode of coiling, in being more evolute, in having its rotaloid aperture at the periphery instead of between the periphery and the umbilicus on the ventral side; and in having supplementary apertures both above and below the periphery.

[1]The writer is indebted to Dr. R. C. Moore for correction of the spelling of this genus. Under Art. 19 of the International Rules of Zoological Nomenclature, Ehrenberg's original "*Loxostomum*" becomes *Loxostoma*, for transliteration of the Greek, *stoma*, is erroneous.

MISSISSIPPINA MONSOURI HOWE, N. SP.
Plate 27, figures 4a-c

Test in early stages trochoid, later becoming almost planispiral, convex on the dorsal side, somewhat umbilicate on the ventral side, all whorls visible on the dorsal side and most of the preceding whorls visible on the ventral side; distinctly umbilicate. Sutures depressed on both dorsal and ventral sides; periphery rounded. Apertures of two sorts, one kind at the base of the last formed chamber at the periphery, the other kind being supplementary apertures elongated in the axis of coiling on both the dorsal and ventral sides of the periphery of each chamber.

Diameter 0.50 mm.

Named in honor of Mr. Eli T. Monsour, paleontologist for the Humble Oil Company.

Holotype from the Byram marl at Byram, Mississippi. Description based on 31 specimens from this locality.

FAMILY NONIONIDAE

GENUS NONIONELLA CUSHMAN, 1926

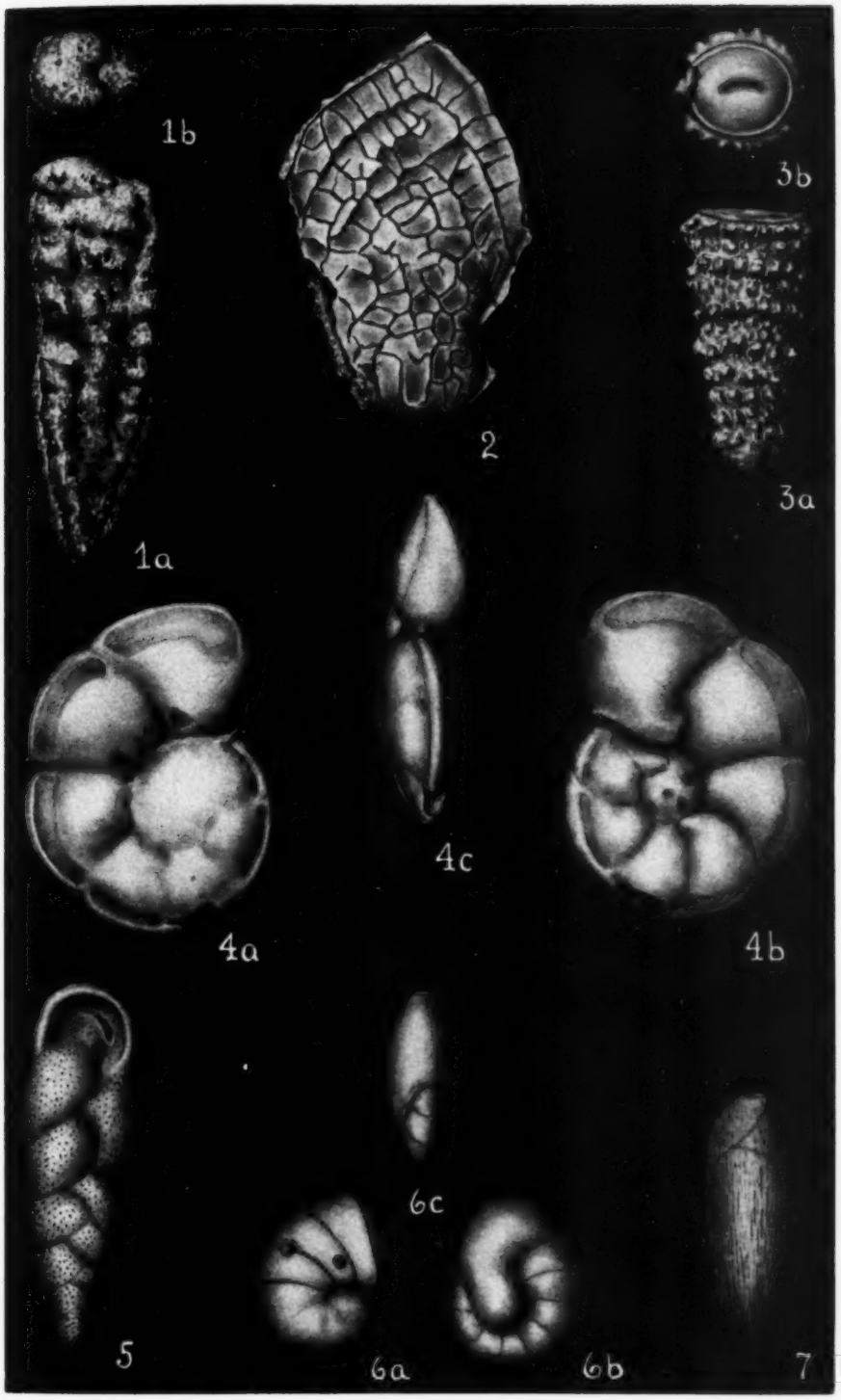
NONIONELLA TATUMI HOWE, N. SP.
Plate 27, figures 6a-c

Test subtrochoid, small, periphery broadly rounded, usually nine chambers in the last formed coil, distinct, dorsal side not completely involute. Sutures nearly straight. Ventral side involute with the last formed chamber having an extension the end of which is generally divided into three or more small lobes which completely cover the umbilical area. Aperture low, arched, at the base of the last formed chamber.

Length 0.30 mm.; breadth 0.25 mm.; thickness 0.10 mm.

EXPLANATION OF PLATE 27

FIGS. 1. *Gaudryina youngi* Howe, n. sp. × 90. *a*, front view; *b*, apertural view.
2. *Flabellina vicksburgensis* Howe, n. sp. × 50.
3. *Tubulogenerina vicksburgensis* Howe, n. sp. × 90. *a*, front view; *b*, apertural view.
4. *Mississippina monsouri* Howe, n. g., n. sp. × 90. *a*, *b*, opposite sides; *c*, peripheral view.
5. *Pleurostomella vicksburgensis* Howe, n. sp. × 90.
6. *Nonionella tatumi* Howe, n. sp. × 90. *a*, *b*, opposite sides; *b*, peripheral view.
7. *Loxostoma hiwaneense* Howe, n. sp. × 90.



UNIV. OF MICH.

Named in honor of Mr. Emmett P. Tatum, paleontologist for the Humble Oil Company. Holotype from the Mint Spring marl, 50 yards below the water falls on Mint Spring Bayou, Vicksburg, Mississippi (37 specimens). This species is present also in the Byram marl at Byram, Mississippi (3 specimens) and in the Red Bluff clay at Hiwannee, Mississippi (7 specimens).

Family ELLIPSOIDINIDAE

Genus PLEUROSTOMELLA Schuchert, 1911

PLEUROSTOMELLA VICKSBURGENSIS Howe, n. sp.

Plate 27, figure 5

Test elongate, biserial, initial end acute, apertural end broadly rounded; chambers unornamented, distinct. Wall calcareous, smooth, coarsely perforate. Sutures depressed. Apertural face of the last formed chamber truncate, depressed; aperture elongate, narrow, terminal, with a lip-like thickening on the sides.

Length 0.60 mm.; width 0.20 mm.

Holotype from the Byram marl at Byram, Mississippi. Description based on 3 individuals from this locality.

Family BULIMINIDAE

Genus TUBULOGENERINA Cushman, 1927

TUBULOGENERINA VICKSBURGENSIS Howe, n. sp.

Plate 27, figures 3a-b

Test elongate, small, first few chambers biserial, rapidly becoming uniserial, chambers round or nearly so in transverse section. Wall calcareous, with a single row of tubuli extending around the median part of each chamber. Aperture elongate, narrow, in the middle of a flattened terminal apertural face.

Length 0.40 mm.; width 0.18 mm.

Holotype from the Byram marl at Byram, Mississippi. Description based on 7 individuals.

Dr. Cushman has kindly checked the determination of this form as a new species and says that it is closely related to the Tertiary species of this genus in Europe.

THE FAUNA OF THE McCOY FORMATION, PENNSYLVANIAN, OF COLORADO

ROBERT ROTH AND JOHN SKINNER
Indian Territory Illuminating Oil Company, Bartlesville, Oklahoma

ABSTRACT

The stratigraphy and lithology of the lower portion of the Carboniferous found at McCoy, Colorado, are described, and the megafauna and microfauna are listed. One new genus and four new species of ostracodes, and eleven new species and three new varieties of foraminifera are described. Splendid specimens have enabled the authors to emend the genus *Deckerella*, show the method of growth of the genus *Bradyina*, and determine the presence of septal pores and very strong chomata in several species of Fusulininae. The genus *Ulrichia* is much restricted.

INTRODUCTION

About two years ago the presence of early Pennsylvanian sediments on the west side of the Rocky Mountains was made known to the senior author by Dr. I. Allen Keyte, of Colorado College, Colorado Springs, Colorado, who very kindly gave specific locations where some of the best collections might be made. The most noteworthy of these is at the postoffice of McCoy, in Eagle County, Colorado. McCoy is located about 92 miles due west of Denver and 41 miles northeast of Glenwood Springs. The Denver and Salt Lake Railroad passes through the area. On the geological map of Colorado, it will be noted that McCoy is situated on the east side of a broad regional uplift, the center of which is north of Glenwood Springs.

The sediments described in this paper comprise the lower part of a massive series of red-beds and arkoses, which is called Middle Carboniferous on the Colorado geological map. The beds have been much folded and faulted, but there is very little metamorphism. The structural conditions make it very hard to obtain a complete geologic column. The 1,000 feet of Pennsylvanian strata that unconformably overlie the undifferentiated Cambro-Ordovician at McCoy is here named the McCoy formation (see Fig. 1). The McCoy formation contains thin beds of very dark limestone and black micaceous shale one to two feet in thickness which are extremely fossiliferous. These beds alternate with very massive conglomerates, the thickness of individual beds running up to 100 feet or more.

FAUNAL CHART OF THE MCCOY FORMATION OF COLORADO

SPECIES	COLLECTIONS					
	178	*177*	*175*	*174*	*183*	*184*
PROTOZOA						
Bradyina magna Roth & Skinner	—	◆	◆	◆	—	—
Climacammina magna Roth & Skinner	—	◆	◆	◆	—	—
Deckerella goessi Roth & Skinner	—	◆	◆	◆	—	—
Endothyra bowmani (Phillips)	—	◆	◆	◆	—	—
Endothyranella minuta (Waters)	—	◆	—	—	—	—
Wedekindella coloradoensis Roth & Skinner	—	◆	◆	◆	—	—
Wedekindella coloradoensis perforata Roth & Skinner	—	◆	—	◆	—	—
Wedekindella excentrica Roth & Skinner	—	◆	◆	—	—	—
Wedekindella excentrica magna Roth & Skinner	—	◆	—	—	—	—
Wedekindella euthusepta (Henbest)	—	◆	—	—	—	—
Fusulina distenta Roth & Skinner	—	◆	—	—	—	—
Fusulina rockymontana Roth & Skinner	—	◆	◆	◆	—	—
Globivalvulina biserialis Cushman & Waters	—	◆	◆	◆	—	—
Globivalvulina bulloides (Brady)	—	◆	◆	◆	—	—
Staffella keytei Roth & Skinner	—	◆	◆	◆	—	—
Staffella sp. large Roth & Skinner	—	◆	—	—	—	—
Tetrataxis concava Galloway & Ryniker	—	◆	◆	◆	—	—
Tetrataxis lata Spandel	—	◆	◆	◆	—	—
Tetrataxis vaccula Roth & Skinner	—	◆	◆	◆	—	—
ANTHOZOA						
Aulopora ? anna Beede	—	◆	—	—	—	—
ANNELIDA						
Serpulopsis insita (White) ?	—	◆	—	—	—	—
ECHINOIDEA						
Echinocrinus aff. *cratis* White	—	◆	—	—	—	—
BRACHIOPODA						
Ambocoelia planoconvexa Shumard	—	—	—	—	◆	—
Chonetes mesolobus Norwood & Pratten, var.	◆	◆	—	—	◆	—
Cliothyridina orbicularis McChesney ?	—	◆	—	—	—	—
Composita subtilita (d'Orbigny)	—	◆	—	—	◆	—
Derbya crassa Meek & Hayden	◆	—	—	—	◆	—
Linoproductus pertenuis (Meek)	—	◆	—	—	—	—
Marginifera splendens Norwood & Pratten	—	◆	—	—	—	—
Meekella sp.	—	—	—	—	◆	—
Orbiculoidea sp.	—	—	—	—	◆	—
Productus aff. *gallatinensis* Girty	—	—	—	—	◆	—
Pustula nebraskensis (Owen)	—	—	—	—	◆	—
Spirifer boonensis Swallow ?	—	—	—	—	◆	—
Spirifer rockymontanus Marcou ?	—	◆	—	—	◆	—
Spiriferina kentuckyensis (Hall) ?	—	◆	—	—	—	—
Squamularia perplexa McChesney	—	◆	—	—	—	—
BRYOZOA						
Fenestella spp.	—	◆	—	—	—	—
Polypora spp.	—	◆	—	—	—	—
Prismopora serrata (Meek)	—	◆	—	—	—	—
Rhombocladia delicata Rogers ?	—	◆	—	—	—	—
Rhombopora spp.	—	◆	—	—	—	—
PELECYPODA						
Astartella concentrica Conrad	—	◆	—	—	—	—
Aviculopecten interlineatus Meek & Worthen	—	◆	—	—	—	—
Leda bellistriata Stevens	—	—	—	—	◆	—
Myalina swallovi McChesney	—	—	—	—	◆	—
Pinna sp.	—	—	—	—	◆	—
Plagiostoma ?	◆	—	—	—	—	—
Schizodus aff. *wheeleri* Swallow	—	—	—	—	◆	—

Species	Collections					
	178	177	175	174	183	184
GASTROPODA						
Euphemus carbonarius Cox	—	◆	—	—	—	—
Meekospira peracuta Ulrich ?	—	◆	◆	◆	—	—
Orestes nodosus Girty	—	—	—	◆	—	—
Sphaerodoma sp.	—	—	—	◆	—	—
CRUSTACEA						
Amphissites centronotus (Ulrich & Bassler)	—	◆	—	—	—	—
Bairdia ardmorensis Harlton	—	◆	—	◆	—	—
Bairdia citriformis Knight	—	◆	◆	◆	—	—
Bairdia dornickhillensis Harlton	—	◆	—	◆	—	—
Bairdia glennensis Harlton	—	◆	◆	◆	—	—
Bairdia hoxbarensis Harlton	—	◆	—	—	—	—
Bairdia pompilioides Harlton	—	◆	◆	◆	—	—
Bairdia subelongata Jones & Kirkby	—	◆	—	◆	—	—
Bairdia ventricosa Roth & Skinner	—	◆	—	◆	—	—
Cyathus ulrichi Roth & Skinner	—	◆	—	—	—	—
Cytherella cf. *valida* Jones & Kirkby	—	◆	—	◆	—	—
Griffithides ?	—	◆	—	—	—	—
Healdia leguminoidea (Knight)	—	◆	◆	◆	—	—
Hollinella bassleri (Knight)	—	◆	—	◆	—	—
Jonesina mccoyi Roth & Skinner	—	◆	◆	◆	—	◆
Kirkbya cf. *clarocarinata* Knight	—	◆	—	◆	—	—
Kirkbya cf. *perplexa* Roth	—	◆	—	—	—	—
Ulrichia binoda Roth & Skinner	—	◆	—	—	—	—
Mauryella sp.	—	◆	—	—	—	—
Paraparchites inornata (McCoy)	—	◆	—	◆	—	—

In September, 1929, the senior author, with the assistance of Mr. O. C. Clifford, Jr., visited McCoy and made collections from the various beds which Dr. Keyte had previously found. This work also included a detailed study of the stratigraphy.

The fauna contained in the McCoy formation furnishes basis for definite correlations with the Amsden and the lower portion of the Hartville formation in Wyoming, with the lower part of the Minnelusa formation in the Black Hills, with the Cherokee shale in northern Oklahoma, and with formations from the Wetumka down to at least the middle portion of the Atoka in south central Oklahoma. Equivalents of the McCoy are also to be found in a part of the Glenn group of southern Oklahoma, in a portion of the Strawn and Bend groups of central Texas, in the lower part of the Gaptank of southwestern Texas and in the Hueco of southern New Mexico. Some of the McCoy fossils are also found in the Tradewater formation of southern Illinois. The lower Fountain in Colorado may be correlated with the McCoy.

The section on Fusulinidae has been prepared by Mr. Skinner. Acknowledgment may be made here of indebtedness to Dr. Carl O.

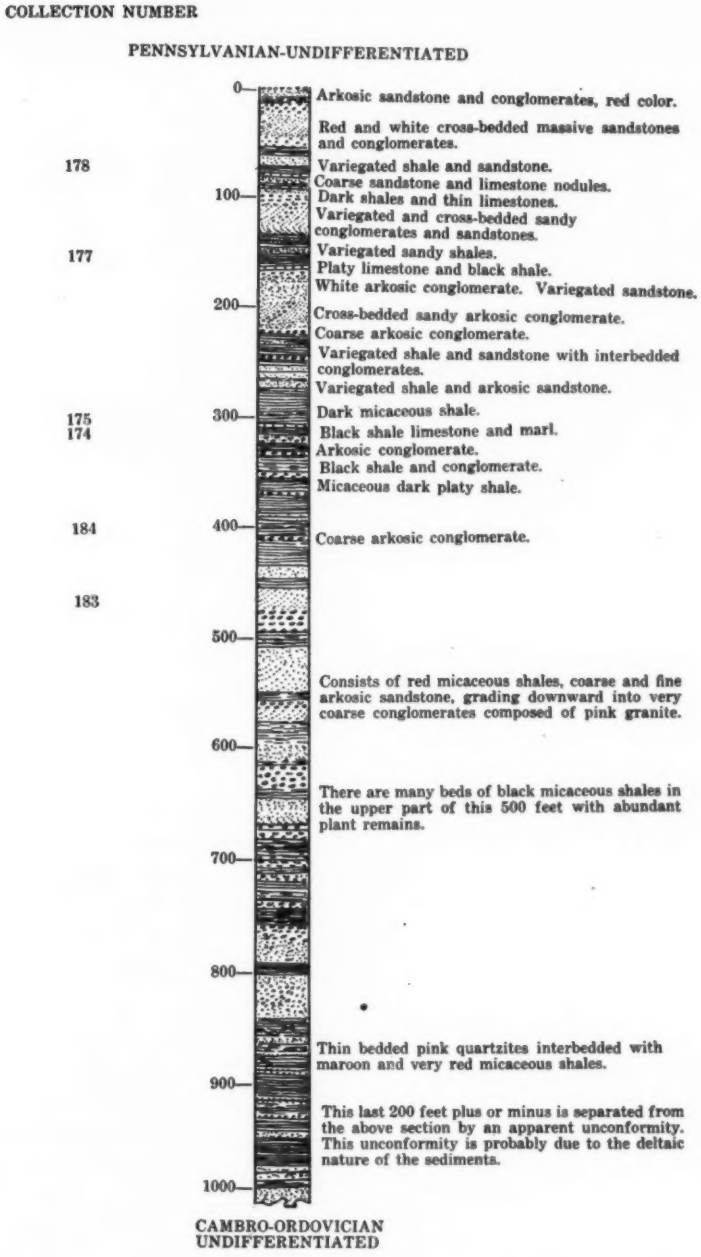

COLLECTION NUMBER
PENNSYLVANIAN-UNDIFFERENTIATED
0
Arkosic sandstone and conglomerates, red color.
Red and white cross-bedded massive sandstones and conglomerates.
178
Variegated shale and sandstone.
Coarse sandstone and limestone nodules.
100
Dark shales and thin limestones.
Variegated and cross-bedded sandy conglomerates and sandstones.
177
Variegated sandy shales.
Platy limestone and black shale.
White arkosic conglomerate. Variegated sandstone.
200
Cross-bedded sandy arkosic conglomerate.
Coarse arkosic conglomerate.
Variegated shale and sandstone with interbedded conglomerates.
Variegated shale and arkosic sandstone.
175
300
Dark micaceous shale.
174
Black shale limestone and marl.
Arkosic conglomerate.
Black shale and conglomerate.
Micaceous dark platy shale.
184
400
Coarse arkosic conglomerate.
183
500
Consists of red micaceous shales, coarse and fine arkosic sandstone, grading downward into very coarse conglomerates composed of pink granite.
600
There are many beds of black micaceous shales in the upper part of this 500 feet with abundant plant remains.
700
800
Thin bedded pink quartzites interbedded with maroon and very red micaceous shales.
900
This last 200 feet plus or minus is separated from the above section by an apparent unconformity. This unconformity is probably due to the deltaic nature of the sediments.
1000
CAMBRO-ORDOVICIAN
UNDIFFERENTIATED

FIG. 1

Dunbar of Yale University for identifying fossils of the megafauna in collection 183, and to Dr. I. A. Keyte for very important field information.

REGISTER OF LOCALITIES IN EAGLE COUNTY, COLORADO

Collection 174. Between secs. 5 and 6, T. 2 S., R. 83 W., where Rock Creek crosses the road, due west of the McCoy Mercantile Company store. The strata here dip about 70 degrees to the west, this dip involving beds from which all of the collections except 183 and 184 were obtained. The collection numbers start with the oldest beds and progress toward the younger (fig. 1). Collection 174 is about 70 feet above, that is, west of, the beds in the bottom of Rock Creek.

Collection 175 is 10 feet above (west of) No. 174.

Collection 177 is 130 feet above (west of) No. 175.

Collection 178 is 70 feet above (west of) No. 177.

Collection 183 is on the Denver and Salt Lake Railway, 600 feet east of tunnel No. 43. It is considered to belong much below collections 174-178.

Collection 184 is on the same railroad southwest of No. 183 and is about 75 feet stratigraphically above it. All types are deposited in the United States National Museum.

DESCRIPTION OF SPECIES

FORAMINIFERA

FAMILY NONIONIDAE MONTFORT, 1808

GENUS BRADYINA MÖLLER, 1878

BRADYINA MAGNA ROTH AND SKINNER, N. SP.

Plate 29, figures 1-4

Test involute, subspherical, nautiloid, faintly umbilicated, bilaterally symmetrical in the adult. In some cases the early two or three chambers differ from the later ones in arrangement. The outside whorl commonly consists of five inflated chambers, but sometimes only four. Sutures are slightly depressed, with a second depression parallelling the suture but enclosing the apertures. The apertures consist of a series of parallel slits, except in the plane of coiling where there are usually three or more; irregular in distribution and outline, the last chamber showing a second row of slits smaller than the first; arcuate over the apertural face and extending over the back part of the chamber. Wall thick, calcareous, finely granular and very coarsely perforate, excepting the portion immediately adjacent to the slit-like apertures. Diameter 2.32 mm., width 1.68 mm.

Sections parallel to the plane of coiling and at right angles to it show interesting features pertaining to the mode of growth. In adding

each new chamber a partition is formed that seals off all of the apertures except those immediately in the center of the apertural face. The wall separating these slits on the apertural face is then torn down, a new chamber with apertures completely surrounding it is developed, and the process is repeated so that one large aperture is left connecting each of the internal chambers, which in some cases amounts to twelve.

This species is closely related to *B. holdenvillensis* Harlton. It may be distinguished, however, by its greater size, a double pair of apertures and more coarsely perforate test.

Collections 174, 175, and 177.

Family ORBITOLINIDAE d'Orbigny, 1847

Genus TETRATAXIS Ehrenberg, 1843

TETRATAXIS VACCULA Roth and Skinner, n. sp.

Plate 29, figures 5-7

Test free or attached by the ventral side to foreign objects, round in dorsal view, ventral side depressed, slightly convex from apex to base or in some cases concave; ventral side concave with widely open vestibule. Whorls very numerous, with as many as fifteen or more chambers to a whorl in the adult stage. Chambers, even the earlier ones, arcuate in shape, becoming relatively broader as added; apparently arranged in spirals; broad on the ventral side circumferentially and short radially; with a prominent projection extending out into the vestibule, the projections of many of the chambers prior to the last whorl being visible. Shell entirely calcareous, with an outer granular layer which is very thin and a thicker interior hyaline alveolar light-colored layer. Aperture a narrow slit visible under the valvular flap opening into the vestibule. Diameter 5.00 mm., height 0.80 mm.

This form is closely related to *T. concava* Galloway and Ryniker, but differs in the larger size and greater number of the chambers and whorls.

Collections 174, 175, and 177.

Family TEXTULARIIDAE d'Orbigny, 1846

Genus DECKERELLA Cushman and Waters, 1928

DECKERELLA GOESSI Roth and Skinner, n. sp.

Plate 28, figures 19-23

Test elongate and in many cases curved, slightly compressed at right angles to the plane of biserial development, and having rounded

edges. The biserial portion tapers rapidly with a depression down the middle. It contains thirteen or more chambers, the uniserial portion subcylindrical, consisting of five to seven chambers, five being the usual number. Suture in the biserial portion curved in the middle of the test and nearly straight toward the edge, slightly depressed toward the aperture. Surface of test uneven and granular or speckled. Wall calcareous, thick, consisting of a slightly perforate inner hyaline layer containing alveoli, and an outer layer which is granular.

Sections of the uniseral chambers show that (1) the aperture of the fifth chamber has usually five but occasionally six or seven openings which are irregular in outline and sometimes in two parallel rows of three openings each; (2) the fourth chamber has four openings in the apertural face, separated by two straight partitions intersecting at right angles, the openings being triangular in outline with the side away from the center arcuate about the center; (3) the third chamber has three openings, separated by three partitions, intersecting at an angle of about 120 degrees, the openings being subtriangular to irregularly ovate in outline, one usually larger than the other two; (4) the second and first chambers (and sometimes the third and fourth chamber) have two ovate openings, straight on the inner side and ovate on the outer side. From the fourth stage on, all of the generic characters are typically displayed.

The under side of the partitions, separating the openings which go to make up the aperture, is highly arched upward. Thus in sectioning

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EXPLANATION OF PLATE 28

FIGS. 1-4.—*Ulrichia binoda* Roth and Skinner, n. sp. 1, right valve, × 25; 2, dorsal aspect, anterior toward right, × 25; 3, ventral aspect, anterior toward right, × 25; 4, anterior aspect, × 25.

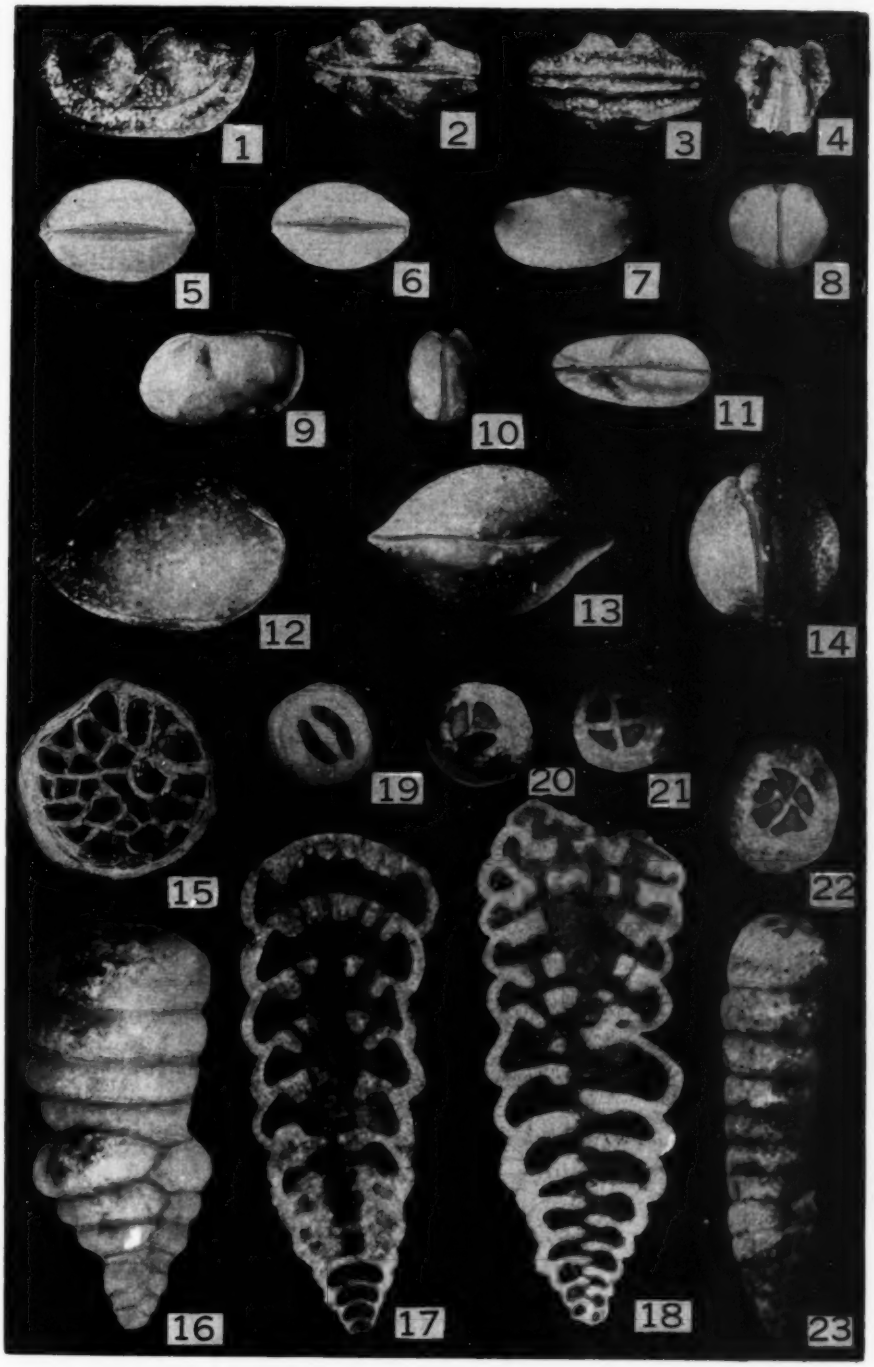
5-8.—*Cyathus ulrichi* Roth and Skinner, n. sp. 5, dorsal aspect, anterior toward right, × 40; 6, ventral aspect, anterior toward left, × 40; 7, right valve, × 40; 8, anterior as pect,× 40.

9-11.—*Jonesina mccoyi* Roth and Skinner, n. sp. 9, right valve, × 25; 10, anterior aspect, × 25; 11, dorsal aspect, anterior toward right, × 25.

12-14.—*Bairdia ventricosa* Roth and Skinner, n. sp. 12, right valve, × 25; 13, dorsal aspect, × 25, anterior toward right; 14, anterior aspect, × 25.

15-18.—*Climacammina magna* Roth and Skinner, n. sp. 16, complete test, × 25; 18, section parallel to plane of biserial development, × 25; 17, section at right angles to section 18, × 25; 15, aperture face, × 25.

19-23.—*Deckerella goessi* Roth and Skinner, n. sp. 23, complete specimen with 7 chambers in uniserial portion, × 25; 19, aperture aspect of the first, second, third, and sometimes fourth, chambers above biserial portion of test, × 25; 20, aperture aspect of fourth chamber, × 25; 21, aperture aspect of fifth chamber, × 25; 22, aperture aspect of sixth and seventh chamber, × 25.



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downward some peculiar conditions are brought out, such as the developing of the aperture into trefoil and quatrefoil outlines with the partitions missing in the center.

With the evidence in hand it is believed that the genus *Deckerella* was described by Cushman and Waters[1] from immature forms, and the same applies to the tests described by Galloway and Ryniker.[2] In many specimens the two-holed aperture has been seen to persist up to the fourth chamber, but it has not been noted above that. Length 2.26 mm., width 0.60 mm.

Collections 174, 175, and 177.

Genus CLIMACAMMINA H. B. Brady, 1876

CLIMACAMMINA MAGNA Roth and Skinner, n. sp.

Plate 28, figures 15-18

Test elongate, imperforate, slightly compressed in a plane at right angles to the plane of biserial development, unsymmetrical, sometimes curved in biserial phase; early chambers biserial or textularian, later ones uniserial, sometimes set on obliquely. Septation imperfect; sutures marked externally by depressed lines; segments numerous, more or less ventricose externally; interior subdivided or labyrinthic. Wall of test quite thick, its inner portion alveolar and outer portion granular, possibly subarenaceous; the entire test is calcareous. There are nineteen or more chambers in the biserial portion, while in the uniserial portion there are five or six chambers.

Sectioning shows the following conditions. Starting with the adult stage, the apertural face of the first chamber contains twenty or more irregular lobed or triangulate openings, which cover almost the entire face, the wall containing these openings being always notably thicker than the rest of the chamber wall. The apertural face of the second chamber is the same as the first, but with a slight decrease in the number of openings which are situated more in the center. The apertural face of the third chamber has a large central circular opening with about ten triangulate openings about its periphery. The apertural face of the fourth chamber has a slightly larger circular opening, becoming lobate, and it has seven or more triangulate peripheral openings. The apertural face of the fifth chamber is about the same as the fourth except that there are generally six peripheral openings, all of which are very lobate. The apertural face of the sixth chamber (usually there are five chambers)

[1]Waters, J. A., Jour. Pal., Vol. 2 (1928), pp. 128-30.

[2]Galloway, J. J., and Ryniker, Chas., Circ. 21, Okla. Geol. Sur. (1930), p. 22.

contains a large aperture which is ovate, with five or six openings in arcuate arrangement about the side of the larger aperture, which is toward the suture or the outside. There is but one large aperture in the biserial stage and this is situated along the central portion of the inner suture. Length 2.80 to 4.00 mm., width 1.12 mm.

This form is similar to *Climacammina* Cushman and Harlton, but may be distinguished by its greater size and different arrangements of the openings forming the aperture.

Collections 174, 175, and 177.

Family FUSULINIDAE Möller, 1877

Subfamily FUSULININAE Staff-Wedekind

Genus WEDEKINDELLA Dunbar-Henbest, 1930

WEDEKINDELLA EXCENTRICA Roth and Skinner, n. sp.

Plate 30, figures 1-3

Test small, slender, tapering slightly toward the ends which are bluntly to acutely pointed. Fully grown specimens have 8½ to 10 whorls and vary in length from 3.8 to 5 mm., and in width from 1.2 to 1.8 mm. The form ratio ranges from 1:2.5 to 1:3.3.

Septa are quite straight, and the lower edge of each septum is connected by a secondary deposit to the floor of the chamber along its entire length, with the exception of that portion which is occupied by the aperture. On each side of the tunnel the lower half of each septum becomes abruptly thickened and fuses laterally with the adjacent septa so that strong ridges or chomata are formed. The apertures are about three times as wide as high. Septa are very thick, measuring about 72μ in the outer whorls. No septal pores are observed. Septal count for two typical individuals follow:

Whorl	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
A.....	12	14	18	20	23	24	26	29	32	32
B.....	8	16	16	22	24	24	27	29	31	incomplete

The tunnel is very crooked and narrow, its angle ranging from 17 to 22 degrees. The proloculum is minute, varying in diameter from 46 to 84μ.

The wall is very thin and does not tend to thicken with growth of the shell. The tectum is not distinguishable in the specimens before us, and is probably extremely thin. The thickness of the various layers

follows: outer secondary deposit and tectum combined, 9μ; diaphanotheca, 11μ; inner secondary deposit, 16μ. These measurements were made on the part of the wall that forms the floor of the tunnel.

W. excentrica is so named because of the extreme crookedness or eccentricity of the tunnel, which wanders back and forth across the middle of the shell. This feature makes it impossible to obtain a sagittal section which does not cut the chomata in several places. It may be remarked here that all measurements of tunnel angles given in this paper are based on the next to the outermost volution in which the tunnel is clearly defined. The septa are so thick and so closely spaced that, in axial section, the interior of the shell seems to be nearly solid.

Collections 175 and 177.

WEDEKINDELLA EXCENTRICA VAR. MAGNA ROTH AND SKINNER, N. VAR.
Plate 30, figures 4-5

Test small, slender, tapering to bluntly pointed ends. Mature shells have 12 to 13½ volutions, varying in length from 4.5 to 5 mm., and in width from 1.7 to 2 mm. Form ratio ranges from 1:2.36 to 1:2.8.

The septa are straight and imperforate, and, as in *W. excentrica* are unusually thick. They are fairly numerous, the count for the figured specimen being ?-?-18-22-23-29-29-32-26-28-32-incomplete.

Chomata are strong, persisting to the last whorl. Tunnel very crooked and narrow, the tunnel angle ranging from 18 to 21 degrees. Initial chamber minute, varying in diameter from 34 to 63μ. The wall is quite thin and the tectum is indistinguishable. Thickness of wall in the tenth volution is about 34μ.

W. excentrica var. *magna* is perhaps the most remarkable of the forms here described in that it possesses a greater number of volutions than any other known American species. Like *W. excentrica*, the tunnel is extremely erratic. It differs from the latter in that it has from 2 to 3 more volutions, and is slightly thicker, though displaying little increase in length. This last character produces a noticeable difference in the form ratio. While *W. excentrica* is quite abundant, the variety *magna* is rare, our entire set containing only six specimens.

Collection 177.

WEDEKINDELLA COLORADOENSIS ROTH AND SKINNER, N. SP.
Plate 30, figures 6-8

Test small, slender, tapering to acutely pointed ends. Mature forms have 8 to 10 whorls. The length varies from 3 to 4.4 mm., and width from 1.2 to 1.5 mm. The form ratio ranges from 1:2.3 to 1:3.

The septa are nearly straight, though in the last two whorls they become slightly folded near the poles. They are notably thinner than in *W. excentrica*, and consequently the chambers are wider, giving a less solid appearance when seen in axial section. The septal count for two typical specimens is as follows:

Whorl	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
A	10	14	17	19	22	23	23	30	32
B	10	13	17	18	19	21	24	25	28

Chomata are fairly strong but usually become obsolete in the outermost whorl. The tunnel is narrow, and, while it is often crooked, is not nearly so erratic as in *W. excentrica*. The tunnel angle varies from 18 to 24 degrees. Diameter of the proloculum ranges from 69 to 94μ. The wall is very thin and the tectum cannot be distinguished. Thickness of outer secondary deposit and tectum combined 15μ; diaphanotheca, 11μ; inner secondary layer 7μ.

W. coloradoensis is closely related to *W. excentrica*, but in the former the septa are much thinner, and they have a tendency to become fluted in the outer whorls, especially near the poles. Because they are thinner, the septa occupy less of the space in the interior of the shell. *W. coloradoensis* is somewhat smaller, and the walls are thinner. Also the tunnel is not nearly so crooked, in many cases being quite straight.

Collections 174, 175, and 177.

EXPLANATION OF PLATE 29

FIGS. 1-4.—*Bradyina magna* Roth and Skinner, n. sp. 1, apertural aspect, × 20. Arrow indicates second row of apertures over the face. It is below this point, indicated by arrow where wall is broken down; 2, section at right angles to plane of coiling, arrow indicating partition which shuts off the apertures, × 20; 3, view parallel to plane of coiling, × 20; 4, section parallel to plane of coiling, arrow indicating partition shutting off apertures, × 20.

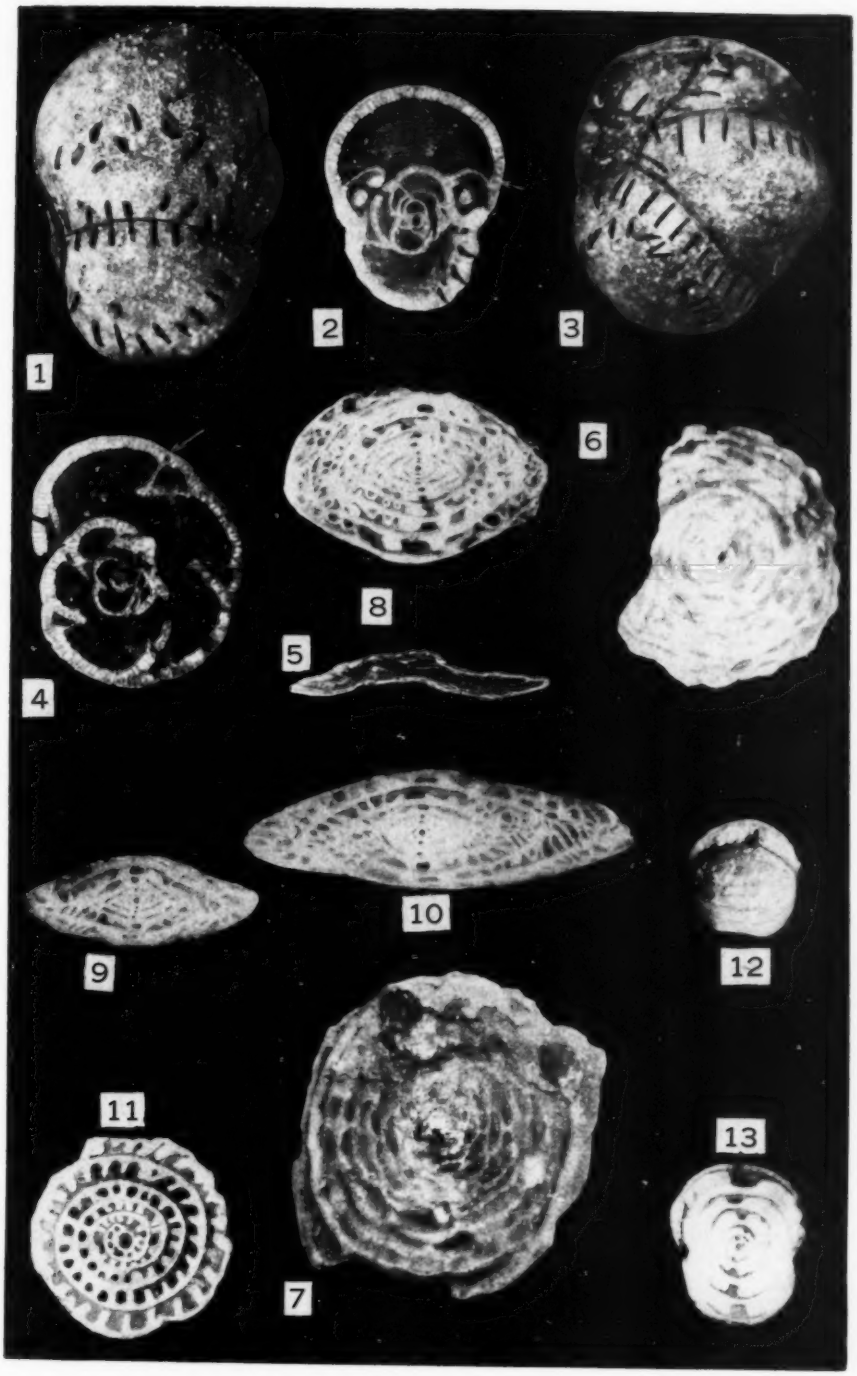
5-7.—*Tetrataxis vaccula* Roth and Skinner, n. sp. 5, section through proloculum at right angles to plane of development, × 8; 6, dorsal aspect of broken specimen, × 8; 7, dorsal aspect of more complete specimen, × 8.

8.—*Fusulina meeki* var. *tregoensis* Roth and Skinner, n. var. Axial section, × 20.

9.—*Fusulina minutissima* Roth and Skinner, n. sp. Axial section, × 20.

10.—*Fusulina hartvillensis* Roth and Skinner, n. sp. Axial section, × 20.

11-13.—*Staffella keytei* Roth and Skinner, n. sp. 11, sagittal section, × 32; 12, entire specimen, showing antetheca, × 20; 13, axial section, showing the strong chomata and relatively wide aperture, × 32.



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WEDEKINDELLA COLORADOENSIS VAR. PERFORATA ROTH AND SKINNER, N. VAR.

Plate 30, figures 9-11

Test small, slender, fusiform, acutely pointed at the ends. Mature specimens vary in length from 3.5 to 4.3 mm., and in width from 1.2 to 1.6 mm. Shells of this size have 8 to 10 whorls. The form ratio ranges from 1:2.5 to 1:2.9.

Septa are slightly fluted from pole to pole, especially after the fifth whorl. This folding is by no means sharp as in *F. distenta*, but consists rather of long, superficial undulations. The fluting is so slight that this form falls in the same group as *W. euthusepta* (Henbest) and *W. excentrica*, and is the only member of that group known to possess septal pores. The pores appear in the seventh volution and become quite coarse and abundant in the eighth. It is from the presence of these pores that the variety name *perforata* is derived. As in *W. coloradoensis*, the septa are quite thin, giving a more open appearance to the interior as seen in axial section. Septal count for three specimens is as follows:

Whorl	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
A.....	10	14	18	22	22	22	25	26	Incomplete
B.....	10	12	15	16	18	20	23	26	Incomplete
C.....	10	12	16	17	19	22	24	26	Incomplete

Chomata are well developed, but disappear in the last whorl. The tunnel angle is fairly large, ranging from 26 to 31 degrees. The proloculum is minute, its diameter ranging from 41 to 77μ. The wall is quite thin, and thickens very little with growth. Measurements taken in the eighth volution are: outer secondary deposit and tectum combined, 9μ; diaphanotheca, 7μ; inner secondary layer, 10μ.

W. coloradoensis var. *perforata* is distinguished from *W. coloradoensis* by its perforate septa, wider tunnel angle, and the fact that the fluting is a little more extensive.

Collections 174 and 177.

GENUS FUSULINA FISCHER, 1837

FUSULINA HARTVILLENSIS ROTH AND SKINNER, N. SP.

Plate 29, figure 10

Test small, fusiform, acutely pointed at the ends. The length varies from 3.1 to 3.2 mm., and the width from 1 to 1.2 mm. The form ratio is 1:2.58 to 1:3.2. Mature shells have 6 to 7 whorls.

The septa are strongly and evenly fluted throughout, but no septal pores have been observed. No septal count can be given at this time,

due to the fact that our specimens occur in a limestone associated with several other species; hence, we have been unable to obtain any sagittal sections which can be definitely assigned to this species.

Chomata are well developed, even in the outermost whorls. The tunnel angle is 27 degrees. The wall is quite thin, measuring only 37μ in the sixth whorl. The initial chamber is very small, having a diameter of about 71μ.

Horizon and locality. This species was first observed in the Hartville limestone, in sec. 8, T. 30 N., R. 68 W., Wyoming. Since that time, it has been found in several wells in western Oklahoma and in northeastern Colorado. A similar form occurs in the top of the Boggy shale in sec. 7, T. 8 N., R. 8 E., Oklahoma, and in a marl at the top of the Bluejacket sandstone in center south line sec. 7, T. 21 N., R. 18 E., Oklahoma. This last form appears to be identical with *F. hartvillensis* in every respect except size, being somewhat larger.

FUSULINA ROCKYMONTANA ROTH AND SKINNER, N. SP.
Plate 31, figures 4-6

Test small, fusiform, ends bluntly to acutely pointed. Mature specimens have 6½ to 7½ volutions and vary in length from 4.25 to 5.2 mm., and in width from 2 to 2.5 mm. Form ratio 1:2 to 1:2.6.

Septa strongly and regularly folded throughout. A few coarse septal pores appear in the fifth whorl, and in the sixth they become extremely abundant. These pores are so coarse and plentiful that their presence can hardly be overlooked even when using so low a magnification as ×7. Septa are fairly numerous, the count for two average specimens being as follows:

Whorl	*1*	*2*	*3*	*4*	*5*	*6*	*7*
A	11	18	23	25	31	30	Incomplete
B	9	14	21	24	32	34	Incomplete

Chomata are very strongly developed, persisting even to the outermost whorl. The tunnel is wider than usual among species of this genus, varying from 25 to 30 degrees. The proloculum is not large, ranging in diameter from 125 to 135μ. The wall reaches its maximum thickness about the end of the third whorl and from that point is fairly constant. The thickness of the outer secondary layer is 18μ, of the tectum 5μ, of the diaphanotheca 9μ, and of the inner secondary layer 14μ.

F. rockymontana bears a closer resemblance to *F. meeki* than to any other species. It agrees very closely in size and shape and number of

whorls, but there the similarity ends. Unlike *F. meeki*, it has true chomata which are very strongly developed, it has a markedly wider tunnel, displays an abundance of coarse septal pores and possesses fewer septa in any given volution. The walls have about the same thickness, but in *F. rockymontana*, the diaphanotheca is only about three-fourths as thick as in *F. meeki*. Any of these characteristics, with the exception of the last, is sufficient to distinguish this species from *F. meeki*, and there is no other described form with which confusion is at all likely.

Collections 174, 175, and 177.

FUSULINA MINUTISSIMA ROTH AND SKINNER, N. SP.
Plate 29, figure 9

Test minute, fusiform, pointed at the ends; length about 1.8 mm., and width about 0.7 mm.; form ratio 1:2.57. Shells of this size possess 5 volutions.

Septa strongly and evenly folded from pole to pole. No septal pores were observed and as in the case of *F. hartvillensis*, no septal count has been obtained.

Chomata are well developed, and persist to the last volution; tunnel angle fairly large, being usually about 29 degrees, walls very thin, measuring 34μ in the fourth whorl; initial chamber minute, being about 58μ in diameter.

Horizon and locality. *F. minutissima* occurs with *F. hartvillensis* in the lower part of the Hartville limestone exposed in sec. 8, T. 30 N., R. 68 W., Wyoming. It has also been found in wells in western Oklahoma.

FUSULINA MEEKI VAR. TREGOENSIS ROTH AND SKINNER, N. VAR.
Plate 29, figure 8

Test small, globular, bluntly rounded at the poles. Length is about 2.2 mm., and width 1.5 mm. Form ratio is 1:1.47. Mature specimens have 8 to 8½ whorls.

Septa strongly folded throughout. No pores observed. Septal count for a typical specimen 10-15-19-22-25-31-incomplete.

Chomata well developed and persistent; tunnel narrow, its angle varying from 19 to 23 degrese; walls thin, measuring 39μ in the seventh volution; proloculum minute, being about 52μ in diameter.

F. meeki var. *tregoensis* closely resembles *F. meeki*, especially in the first seven whorls. The tunnel angle and thickness of the walls agree very closely, as does the degree of septal fluting However, it is much smaller and more tumid, the form ratio being decidedly different.

Horizon and locality. This interesting form was first observed in Central Commercial's King No. 1 in sec. 20, T. 13 S., R. 21 W., Trego County, Kansas. It is quite abundant in a reddish brown shale from 3,850 to 3,960 feet. This horizon is of Cherokee age. Subsequently, it has been found at approximately this same horizon in other wells. A single specimen which strongly resembles this form has been found 500 feet below the top of the Atoka formation in the NW. of sec. 10, T. 5 N., R. 21 E., Oklahoma.

FUSULINA DISTENTA ROTH AND SKINNER, N. SP.
Plate 31, figures 1-3.

Test small, extremely ventricose-fusiform to sub-spherical, ends bluntly rounded. Mature shells possess 8 to 9 volutions and vary in length from 4.5 to 4.8 mm., and in width from 2.5 to 2.8 mm. Form ratio 1:1.7 to 1:1.8.

The septa are strongly and evenly folded from pole to pole, and, in the eighth volution, numerous fairly coarse septal pores appear, though they are not so abundant as in *F. rockymontana*. Septa are quite numerous, the count for two representative specimens being:

Whorl	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
A.....	11	19	26	27	37	39	42	Incomplete
B.....	10	22	25	28	33	40	38	Incomplete

Chomata are strongly developed and persist to the outermost whorl. The tunnel is narrow, the angle varying from 17 to 20 degrees. The initial chamber is small, ranging in diameter from 96 to 132μ. The wall is thin and there is little variation in thickness after the first whorl. Thickness of the various layers is as follows: outer secondary layer 12μ, tectum 4μ, diaphanotheca 11μ, and inner secondary layer 37μ.

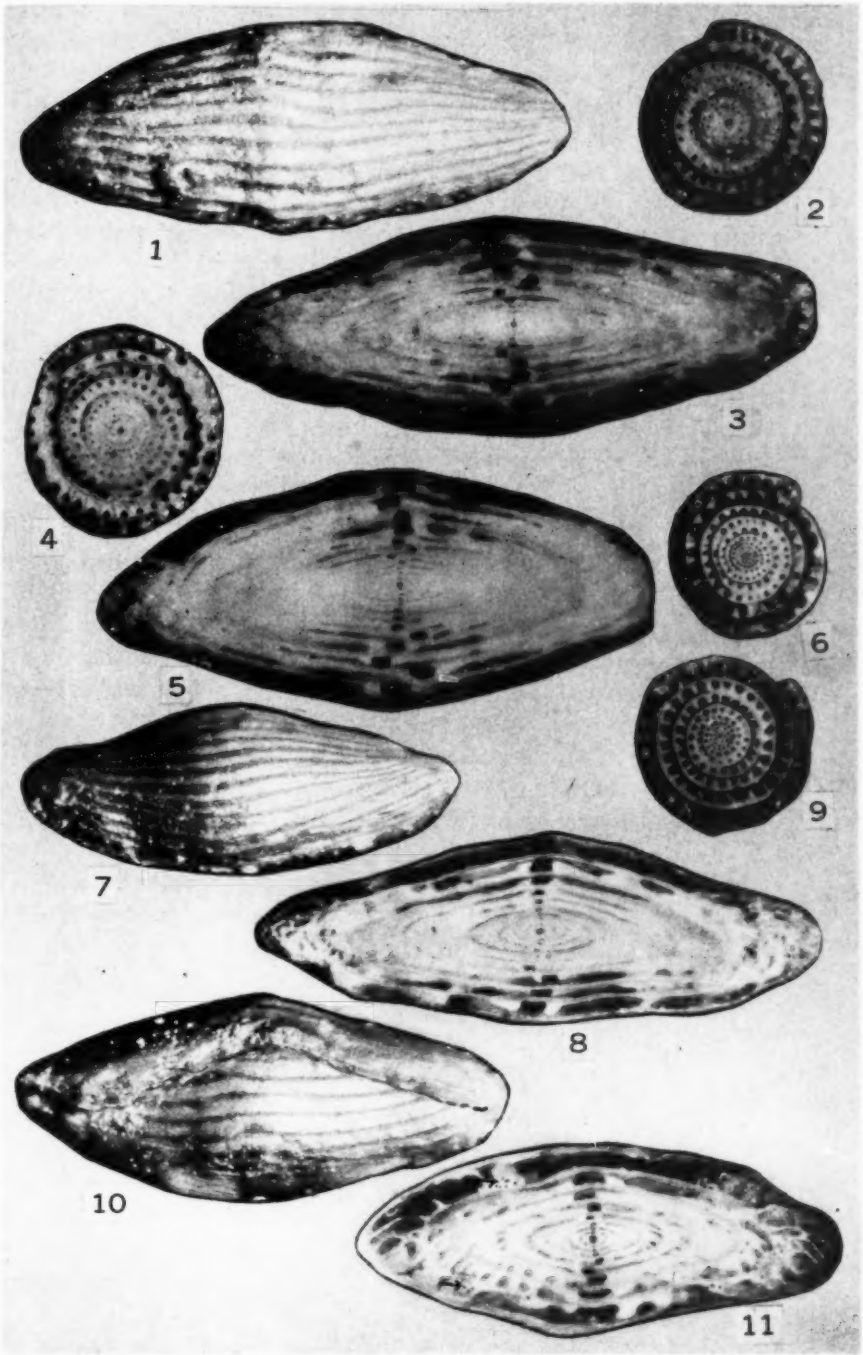
EXPLANATION OF PLATE 30

FIGS. 1-3.—*Wedekindella excentrica* Roth and Skinner, n. sp. 1, entire specimen, × 20; 2, sagittal section, × 20. The chomata are cut in several places due to the eccentricity of the tunnel; 3, axial section, showing the erratic course of the tunnel, × 20.

4-5.—*Wedekindella excentrica* var. *magna* Roth and Skinner, n. var. 4, sagittal section, × 20; 5, axial section of a specimen having 13 whorls, × 20.

6-8.—*Wedekindella coloradoensis* Roth and Skinner, n. sp. 6, sagittal section, × 20; 7, entire specimen, × 20; 8, axial section, showing slight fluting of septa near poles, × 20.

9-11.—*Wedekindella coloradoensis* var. *perforata* Roth and Skinner, n. var. 9, sagittal section, × 20; 10, entire specimen, × 20; 11, axial section, showing fluted septa and septal pores (arrows), × 20.



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F. distenta closely resembles *F. girtyi* in size and shape, though the latter tends to be slightly more ventricose. In other characteristics, however, the similarity is slight. The more outstanding differences are the possession of strongly developed chomata, the presence of septal pores, and a wider tunnel. Its occurrence stratigraphically, and the fact that a number of forms are found in zones 177-D and 177-E which seem to be gradational, suggest that *F. distenta* may have been derived from *F. rockymontana*. However, the fact that the section studied aggregates only about 100 feet in thickness, makes any such conclusion extremely tentative.

Collection 177.

GENUS STAFFELLA OZAWA, 1925

STAFFELLA KEYTEI ROTH AND SKINNER, N, SP.
Plate 29, figures 11-13

Test minute, sub-globular, the axis of coiling being the shortest diameter. Length 0.55 mm., and width 0.64 mm. Form ratio is about 1:0.86. Shells of this size possess about 5 whorls.

The numerous septa are straight, or nearly so, and apparently are not porous. Septal count of the figured specimen is 10-16-19-22-26.

Chomata are strongly developed, especially for a shell having such thin walls. Aperture rounded, relatively large but increasing very slowly with the growth of the shell. The tunnel angle measures approximately 15 degrees. Proloculum minute, varying from 31 to 60μ in diameter. Walls very thin, measuring about 24μ in the fourth whorl and displaying typical non-alveolar structure.

The species is named for Dr. I. A. Keyte of Colorado Springs.

Collections 174, 175, and 177.

OSTRACODA

FAMILY APARCHITIDAE ULRICH AND BASSLER, 1923

GENUS CYATHUS ROTH AND SKINNER, N. G.

CYATHUS ULRICHI ROTH AND SKINNER, N. SP.
Plate 28, figures 5-8

Carapace very small and more or less canoe-shaped. Maximum length midway between the dorsal and ventral margin; maximum width about one-third of the distance from the anterior to the posterior margin; maximum breadth in the plane of the maximum length and width. The

carapace has a faint backward swing, thus indicating the posterior end. There appears to be no pronounced valvular overlap. The dorsal margin is straight and its length is only slightly less than the maximum length; in the middle portion both valves extend slightly above the hinge-line. The entire length of the dorsal margin is marked by a depressed V-shaped trough along the hinge-line. This depression becomes a sharp ridge just before reaching the anterior and posterior cardinal angles. The hingement is simple in outward appearance; the central margin is gently arcuate and depressed so that it is not visible when viewed from the side and is inclined slightly toward the anterior cardinal angle. Anterior extremity gently curved and meeting the hinge-line at an angle of about 170 degrees; posterior extremity gently curved, but meeting the hinge-line at an angle of about 150 degrees. There are no false keels or nodes.

The whole surface of the carapace is covered by a system of concentric faintly oscillating and bifurcating riblets, which parallel the free margin and the hinge line, and are concentric about a point roughly coinciding with the area of maximum breadth. These riblets are most pronounced in the depressed area paralleling the free margin; no pit is observable. Maximum length 0.52 mm., maximum width 0.34 mm., maximum height 0.28 mm.

The authors are aware of no form resembling the one described above: the surface ornaments remind one of the genus *Graphiodactylus*, but there are no other similarities. *C. ulrichi* is the genotype and at present the only known species assignable to *Cyathus*.

Collection 177.

Family KLOEDENELLIDAE Ulrich and Bassler, 1923

Genus JONESINA Ulrich and Bassler, 1909

JONESINA MCCOYI Roth and Skinner, n. sp.

Plate 28, figures 9-11

General outline subelliptical, with a backward swing. Maximum length midway between the ventral and dorsal margins and inclined slightly toward the posterior ventral portion; maximum height just posterior to the sulci; maximum breadth in the plane of maximum length and about one-fifth of the distance along the line of maximum length toward the posterior. The posterior end may be recognized as being the most pinched and containing the sulci. The left valve overlaps the right valve rather faintly through the extent of the free margin. Dorsal margin straight for about two-thirds of the maximum length of the shell,

its anterior cardinal angle just a trifle posterior to the anterior termination of the maximum length; its posterior termination about one-fourth of the distance toward the anterior from the posterior extremity. From the sulci forward both valves swell up above the hinge-line, thus leaving it marked by a V-shaped depression; this depression is greatest in the plane of maximum breadth. About half way from the sulci to the posterior extremity is the posterior cardinal angle; this portion of the dorsal margin is very pinched which leaves the hinge-line standing up as a sharp ridge. The hingement is simple The ventral margin is more or less straight and is slightly inclined toward the anterior cardinal angle. In some forms it is a little concave just in front of the sulci. The anterior extremity is very bluntly curved upward to the anterior cardinal angle which it meets at an angle of about 95 degrees; the posterior extremity is very uniformly curved and meets the posterior cardinal angle at about 160 degrees. There are no false keels. However, the left valve has a faint ridge extending along the entire free margin. Between it and the free margin there is a slight depression and then a small flange; the right valve bends downward and is depressed so that it may fit under this flange. There are no nodes or reticulations. A sulcus occurs on each valve just in front of the posterior cardinal angle. It resembles an elongate dent and is at right angles to the plane of maximum length, which inclines it slightly toward the anterior ventral portion of the carapace. Back of this sulcus there is a very faint depression parallelling a small portion of the posterior extremity where it joins the posterior cardinal angle. This depression is absent in most forms. Maximum length 0.88 mm., maximum width 0.40 mm., maximum height 0.48 mm.

This species may be distinguished from all others by an absence of reticulations, or beads, absence of anterior dorsal and posterior ventral spines, and by the occurrence of only one sulcus on each valve.

Collections 174, 175, 177, and 184.

Family KIRKBYIDAE Ulrich and Bassler, 1906

Genus ULRICHIA Jones, 1890

ULRICHIA BINODA Roth and Skinner, n. sp.

Plate 28, figures 1-4

Carapace subrectangular with a faint backward swing; maximum length along the hinge-line; maximum width about three-quarters of the distance from the anterior to the posterior extremity. The maximum breadth is at right angles to the maximum height, a trifle closer to the

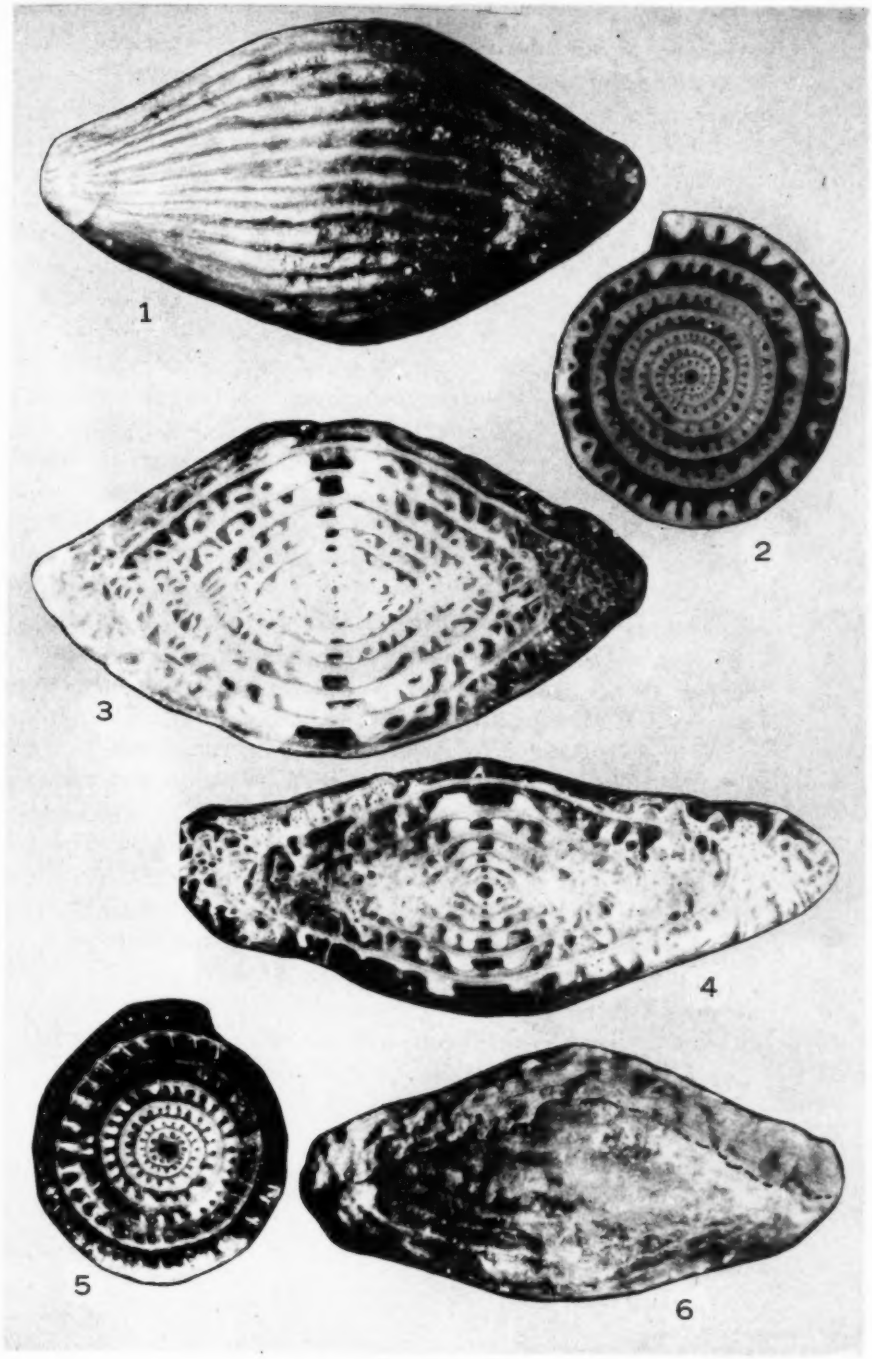
dorsal margin than the ventral, and in the plane of maximum height; it may be measured across the posterior nodes. Orientation of the valves may be determined by the backward swing. Valvular overlap is not pronounced, but along the free margin the left valve faintly overlaps the right. The dorsal margin is straight, and excepting along the anterior and posterior extremities, is marked by a strong V-shaped groove which is most pronounced in the region of the nodes. The hingement is simple, consisting of a ridge on the left valve and a groove on the right valve. The termination of the cardinal angles is not marked by pronounced teeth and sockets. The ventral margin is gently arcuate; the anterior extremity is bluntly and rapidly arched so as to meet the hinge-line in a right angle; the posterior extremity is like the anterior except that it is arched a little more, thus making the posterior cardinal angle a little greater than a right angle.

The carapace has three false keels on each valve. The first false keel is not very pronounced but is continuous for the entire length of the free margin and is parallel to the plane of junction of the valves. The right valve has a shelf extending outward from the first false keel, which is overlapped by a flange similarly extending outward from the left valve; this flange and shelf decrease in width toward the cardinal angles; the flange abuts the first false keel of the right valve. The second false keel is by far the most pronounced and extends along the entire free margin, parallelling the first false keel. It is separated from the first by a groove which decreases in width toward the cardinal angles. When perfectly preserved it sextremity is not crenulated but is smooth. The second false keel stands out at an angle of about 90 degrees to the plane of the free margin. This angle of inclination decreases to about 60 degrees along the ventral margin. The third false keel is really a costa, which parallels the second keel and fades out in the anterior and posterior extremities at a point about midway between the dorsal and ventral margins. The costa seems to be rather an enlarged development of the partitions, separating the reticulations.

EXPLANATION OF PLATE 31

FIGS. 1-3.—*Fusulina distenta* Roth and Skinner, n. sp. 1, entire specimen, × 20; 2, sagittal section, × 20; 3, axial section, showing the strong chomata, × 20.

4-6.—*Fusulina rockymontana* Roth and Skinner, n. sp. 4, axial section, showing the fusulinellid wall-structure and abundant septal pores, × 20; 5, sagittal section, × 20; 6, entire specimen, showing the antethecal × 20.



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The nodes are extremely pronounced. The anterior one is elongate in a plane at right angles to the hinge-line, rising abruptly from the carapace and extending considerably above the dorsal margin. The posterior node is elongate in a line slightly inclined to the anterior ventral portion and is developed the same as the anterior node, also extending above the hinge-line, though not as far. These nodes are better developed in this species than in any yet observed. Reticulations are roughly hexagonal in outline and well developed, covering all portions of the carapace except the pit, the second false keel, and the overlapping shelf of the left valve. They are smallest on the nodes. The pit is situated immediately under the posterior node and toward the anterior ventral side. It is about the size of five of the reticulations and is inclined toward the anterior cardinal angle. Maximum length 1.16 mm., maximum width 0.52 mm., maximum height 0.60 mm.

Generic relations are very close to *Kirkbya*, the characters of both genera being the same in every respect except for the nodes. This similarity is especially strong when one considers the nodes in *K. perplexa* Roth. *Ulrichia*, as here described, is probably a specialized form of *Kirkbya*. Specific relationships are close to *U. montosa* Knight, but our species may be distinguished by the presence of the costa, by its larger pit, and by the unusual development of the nodes, both of which extend above the hinge line. It may be distinguished from *U. bituberculata* (McCoy) by the greater development of the nodes, the presence of reticulations between the first and second false keels, by having a more backward swing and a more distinctly defined pit. *U. conradi* Jones differs in having a smaller anterior node, a subovate outline, and in lacking costae. *U. aequalis* Ulrich and Bassler is larger and has subequal tubercles, besides differing in other characters from *U. binoda* as does *U. conradi*. Jones instituted the genus *Ulrichia* to receive previously described forms and some new ones, and later extended it to include almost any form which had two nodes or otherwise generally resembled the genotype. From this unnatural association the following should be removed: *Ulrichia nicholsoni* Jones, *Ulrichia marrii* Jones, *Ulrichia* sp. ? Jones (Q. J. G. S. Vol. 49, 1893), *Ulrichia girvanensis* Jones, and *Ulrichia grayae* Jones.

Collection 177.

FAMILY BAIRDIDAE ULRICH AND BASSLER, 1923

GENUS BAIRDIA MCCOY, 1844

BAIRDIA VENTRICOSA ROTH AND SKINNER, N. SP.
Plate 28, figures 12-14

Carapace bluntly rhomboidal in outline, very massive, tumid; maximum length slightly inclined upward toward the anterior and about midway between the ventral and dorsal margins; maximum height midway between the anterior and posterior terminations; maximum breadth at right angles to the maximum height; posterior extremity the more acuminate. The left valve pronouncedly overlaps the right valve everywhere except along the anterior ventral margin and the posterior ventral extremity, where the overlap is very faint. Along the dorsal margin the right valve is slightly depressed into the overlapping left valve. This margin is bow-shaped, being arched in the middle, but bends back again at the terminations. The hingement is simple and is marked by a pronounced depression for about one-half of the maximum length and is just under the maximum height. The ventral margin is gently arcuate, and increases rapidly along the anterior ventral portion. The overlapping portion is quite depressed from the region of maximum height backward to about half-way toward the posterior extremity. Anterior extremity bluntly rounded; posterior extremity bluntly acuminate; surface covered by minute pits. There are no other ornaments. Maximum length 1.36 mm., maximum width 0.90 mm., maximum height 0.80 mm.

The specific relations are few. The extreme tumidity of the form separates it from all others. It somewhat resembles *B. juddiana* Jones.

Collections 174 and 177.

MIOCENE FORAMINIFERA FROM BUFF BAY, JAMAICA

JOSEPH A. CUSHMAN AND P. W. JARVIS
Sharon, Massachusetts, and Trinidad, British West Indies

ABSTRACT

Miocene foraminifera are known from the Bowden marl of Jamaica, but the collection from Buff Bay contains a larger fauna from deeper water. The species are closely related to those of Trinidad, Venezuela and Ecuador, also to the Pliocene of southern Italy.

The small collection on which the following descriptions are based is of more than usual interest. The knowledge of the foraminifera from the Miocene of Jamaica is largely confined to what is known of the collections from the Bowden marl from the type locality of Bowden. While the Bowden fauna is a small one, some of the species are of large size, and occur in great numbers. Their living representatives indicate that the Bowden was deposited in waters of less than 100 fathoms. In contrast to this, the foraminifera from Buff Bay represent a somewhat deeper water deposition, perhaps from 100 to 200 fathoms, and the fauna is much larger and of more varied character.

The relationship of this fauna with those of other ages and localities is interesting. As would be expected, many of the species are identical with those now found living in the waters of the West Indian region. Others are very close or identical with those of the Miocene or Pliocene of Europe, especially of Italy. Much of the Pliocene of southern Italy was deposited in waters of some considerable depth. The Buff Bay collection contains also numerous species that have already been recorded from the Miocene of Trinidad, Venezuela and Ecuador. The Gatun formation of Panama indicates that during Miocene times, there was a fairly deep water connection from the Atlantic to the Pacific. The similarity of the Ecuador material with that of Trinidad, Venezuela, and some parts of Mexico, shows that there was probably a very great similarity of conditions over much of this area at that time.

It is with the hope of giving further light on the depths and conditions of deposition of these foraminiferal materials as well as to place on record the fauna itself that the following notes are given.

FAMILY REOPHACIDAE

GENUS HAPLOSTICHE REUSS, 1861

HAPLOSTICHE DUBIA (D'ORBIGNY) VAR. INTERMEDIA (VANDEN BROECK)

Plate 32, figure 1

Lituola soldanii JONES AND PARKER, var. *intermedia* VANDEN BROECK, *1876*, Ann. Soc. Belg. Micr., Vol. 2, p. 74, pl. 2, figs. 1, 3, 4, 6.
Lituola soldanii JONES AND PARKER, *1876*, Ann. Soc. Mal. Belg., Vol. 11, p. 98; HILL, *1899*, Bull. Mus. Comp. Zoöl., Vol. 34, p. 147.
Haplostiche dubia (D'ORBIGNY), var. *intermedia* CUSHMAN, *1919*, Publ. 291, Carnegie Inst. Washington, p. 30, pl. 6, figs. 1-4; *1920*, Bull. 104, U. S. Nat. Mus., pt. 2, p. 35, pl. 7, fig. 4.

Test elongate, subcylindrical, tapering gradually from the broad apertural end to the almost pointed initial end, chambers numerous, 10 to 12, hemispherical, the proximal portion overlapping the preceding chamber, sutures excavated, chambers in a linear series with a straight axis or often curved or sharply bent toward the distal end; wall composed of agglutinated sand grains with occasional tests of other foraminifera; aperture terminal, central, usually somewhat dendritic; interior of chamber labyrinthic, in transverse section showing the subdivisions arranged in radial manner.

Length up to 6 mm.

This form has been known from the Miocene of Jamaica from the Bowden marl of Bowden. It occurs also in 84 to 100 fathoms off the Barbadoes in a living state. The figured specimen which is probably a microspheric one has a more tapering form than most of those of Bowden, but is otherwise identical.

FAMILY TEXTULARIIDAE

GENUS TEXTULARIA DEFRANCE, 1924

TEXTULARIA FLORIDANA CUSHMAN

Plate 32, figures 2a, b

Textularia transversaria FLINT (not H. B. Brady), *1897* (*1899*), Rep. U. S. Nat. Mus., 8, p. 283, pl. 28, fig. 4.
Textularia floridana CUSHMAN, *1922*, Publ. 311, Carnegie Instit. Washington, p. 24, pl. 1, fig. 7; *1922*, Bull. 104, U. S. Nat. Mus., pt. 3, p. 18, pl. 2, figs. 11, 12.

Test elongate, 2 or 3 times as long as wide, much compressed, periphery acute, except in the last-formed chambers, the ends of the chambers forming tubular projections, but often broken, initial end pointed, apertural end broadly rounded; chambers numerous, thickest near the center, increasing somewhat in height toward the apertural end; sutures slightly if at all depressed, only slightly oblique; wall finely arenaceous,

usually smoothly finished; aperture small, rounded, at the base of the inner margin of the last-formed chamber.

Length slightly more than 1 mm.

This species which is fairly common at moderate depths off the Florida coast, is present in the Buff Bay Miocene. The figured specimen shows a break with the last few chambers higher, a feature also seen in some of Dr. Flint's specimens and in our Recent material. This is apparently the first fossil record for the species.

Family VERNEUILINIDAE

Genus TRITAXILINA Cushman, 1911

TRITAXILINA ATLANTICA Cushman

Plate 32, figure 5

Tritaxilina caperata H. B. Brady (part), *1884*, Rep. Voy. *Challenger*, Zoölogy, Vol. 9, p. 390, pl. 49, figs. *3a, b* (not figs. 1, 2, 4-7).

Tritaxilina caperata H. B. Brady, var. *atlantica* Cushman, *1922*, Bull. 104, U. S. Nat. Mus., pt. 3, p. 79, pl. 15, figs. 1, 2.

Tritaxilina atlantica Cushman, *1925*, Contr. Cushman Lab. Foram. Res., Vol. 1, pt. 3, p. 64.

Test rapidly increasing in diameter from the subacute base, the sides for the most part nearly parallel, slightly contracted toward the apertural end, early portion triserial, roughly triangular in transverse section, angles rounded; chambers fairly distinct; sutures slightly depressed; wall arenaceous; aperture of the triserial and biserial portions very small, subcircular at the inner margin of the apertural face.

Maximum length 1.75 mm.

This species is found living in the West Indian region at moderate depths, and it is not surprising to find it fossil in the Miocene of Jamaica. Its nearest relative is *Tritaxilina mexicana*, found in the Eocene of Mexico, but that species was more highly developed and became extinct, with the simpler *T. atlantica* living in the Atlantic and the more highly developed *T. caperata* now confined to the Indo-Pacific.

Genus CLAVULINA d'Orbigny, 1826

CLAVULINA HUMILIS H. B. Brady, var. MEXICANA Cushman

Plate 32, figure 3

Clavulina parisiensis d'Orbigny, var. *humilis* Flint (not H. B. Brady), *1897 (1899)*, Rep. U. S. Nat. Mus., p. 289, pl. 36, fig. 1.

Clavulina humilis H. B. Brady, var. *mexicana* Cushman, *1922*, Bull. 104, U. S. Nat. Mus., pt. 3, p. 83, pl. 16, figs. 1-3.

Test elongate, early portion sharply triangular, with a subacute apical end, later portion subcylindrical, slightly tapering; chambers of

the early portion becoming somewhat more separate and distinct as added, those of the last-formed portion flask-shaped with a definite neck; sutures indistinct in the triserial portion, those of the later portion becoming somewhat more distinct and depressed; wall coarsely arenaceous, the surface roughened, fairly thick; aperture terminal, central, at the end of the tubular neck.

Length up to 2 mm.

This is fairly common as a living form at depths of around 200 fathoms in the Gulf of Mexico and West Indian region, although its range of depth is much greater, but it only occurs commonly at this moderate depth. The Miocene specimens from Buff Bay are identical with the living ones.

CLAVULINA COMMUNIS D'ORBIGNY
Plate 32, figure 4

The specimen figured represents the only specimen in the Buff Bay collection which can be referred to this species. It is a somewhat broken and abnormal specimen.

FAMILY MILIOLIDAE

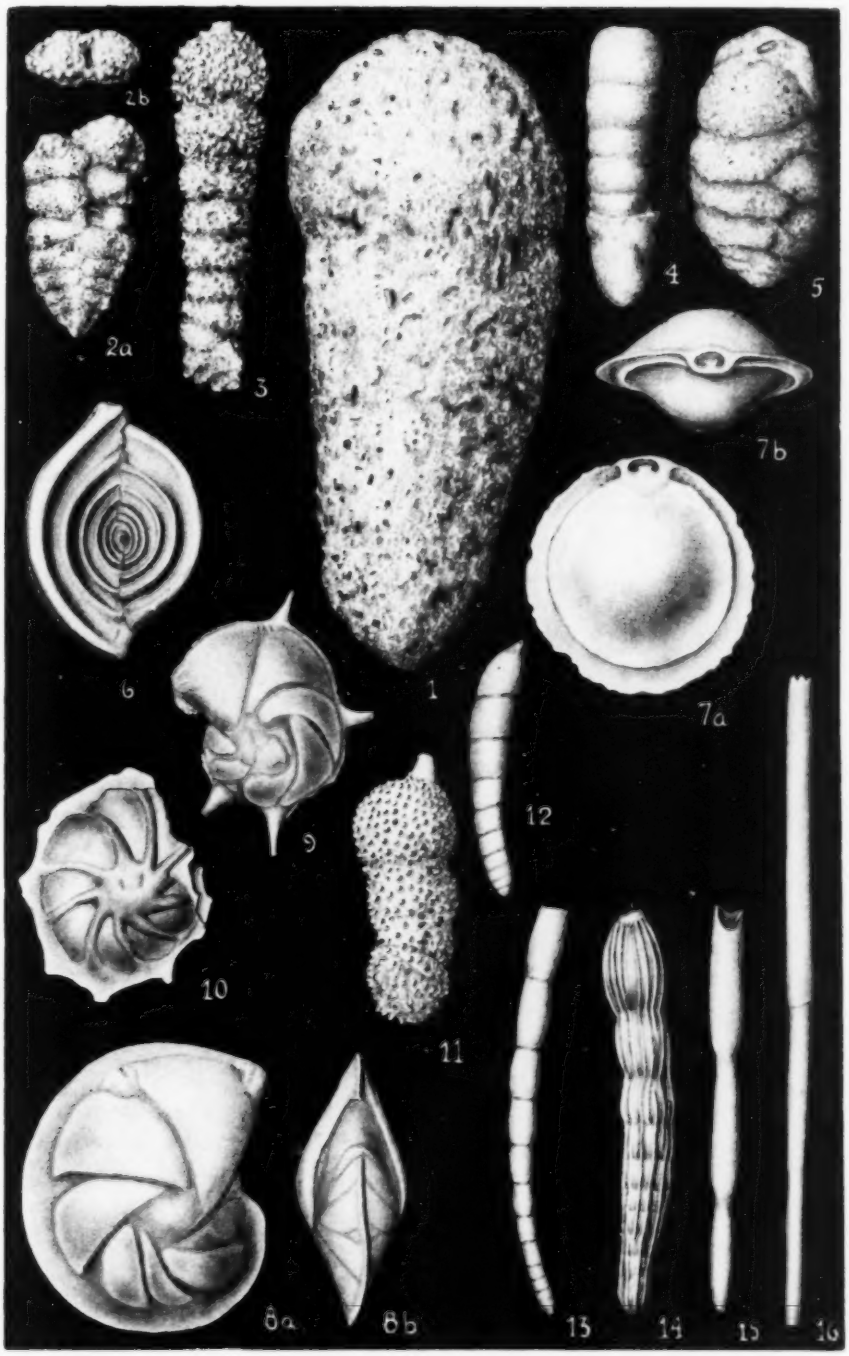
GENUS SPIROLOCULINA D'ORBIGNY, 1826

SPIROLOCULINA DEPRESSA (?) D'ORBIGNY
Plate 32, figure 6

There is much confusion as to the species of *Spiroloculina* named by d'Orbigny which should be applied to forms such as that figured here.

EXPLANATION OF PLATE 32

FIGS. 1.—*Haplostiche dubia* (d'Orbigny), var. *intermedia* (Vanden Broeck), × 30.
2a, b,—*Textularia floridana* Cushman, × 30. a, front view; b, apertural view.
3.—*Clavulina humilis* H. B. Brady, var. *mexicana* Cushman, × 30.
4.—*Clavulina communis* d'Orbigny, × 40.
5.—*Tritaxilina atlantica* Cushman, × 35.
6.—*Spiroloculina depressa* (?) d'Orbigny, × 30.
7a, b.—*Pyrgo murrhina* (Schwager), × 30. a, front view; b, apertural view.
8a, b.—*Robulus occidentalis* (Cushman), var. *torridus* (Cushman), × 40. a, side view; b, apertural view.
9.—*Robulus calcar* (Linné), × 30.
10.—*Robulus formosus* (Cushman), × 30.
11.—*Marginulina aculeata* Neugeboren, × 30.
12.—*Vaginulina clavata* Costa, × 35.
13.—*Dentalina inornata* d'Orbigny, × 30.
14.—*Dentalina bifurcata* d'Orbigny, × 30.
15, 16.—*Nodosaria longiscata* d'Orbigny, × 30.



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The sides are excavated, and the periphery of each chamber greatly thickened, the whole test very slightly longer than broad.

GENUS PYRGO DEFRANCE, 1824

PYRGO MURRHINA (SCHWAGER)

Plate 32, figures 7a, b

Biloculina murrhina SCHWAGER, *1866*, *Novara*-Exped., Geol., Vol. 2, p. 203, pl. 4, figs. 15*a-c*.
Pyrgo murrhina CUSHMAN, *1929*, Bull. 104, U. S. Nat. Mus., pt. 6, p. 71, pl. 19, figs. 6, 7.

Test in front view, in young specimens, nearly circular, in adult specimens somewhat longer than broad, in end view ellipsoid, with the borders extended and carinate, the carina interrupted at the point opposite the aperture, leaving a sinus, rather deep and often with a long spine at each angle in young specimens; in adults, sinus less deep, and the spines usually reduced or wanting; wall smooth; aperture in the young with a neck not exceeding the periphery of the test; in adults with a prominently exserted tubular neck with a bifid tooth partially filling the nearly circular opening.

Diameter up to 1.5 mm.; thickness 0.50 mm.

The figured specimen belongs to this species even though the portion of the keel opposite the aperture is not excavated. It is a widely distributed species, most common in rather deep water. It is rare at Buff Bay. The second reference above will give citations for many of the records of this species.

FAMILY LAGENIDAE

GENUS ROBULUS MONTFORT, 1808

ROBULUS OCCIDENTALIS (CUSHMAN), VAR. TORRIDUS (CUSHMAN)

Plate 32, figures 8a, b

Cristellaria occidentalis CUSHMAN, var. *torrida* CUSHMAN, *1923*, Bull. 104, U. S. Nat. Mus., pt. 4, p. 105, pl. 25, fig. 1.

Variety differing from the typical in the very translucent character of the test and the keel which is thin and transparent, 7 or 8 chambers in the last-formed coil, the aperture not distinctly projecting as in the typical.

Diameter up to 2 mm.

This variety was described from Recent material from the Gulf of Mexico at depths of 56 to 843 fathoms. The Miocene specimens from Buff Bay are identical.

ROBULUS CALCAR (LINNÉ)
Plate 32, figure 9

Rare specimens with peripheral spines like that figured occur in the Buff Bay material. The species occurs in the Miocene of Trinidad, Venezuela and Ecuador.

ROBULUS FORMOSUS (CUSHMAN)
Plate 32, figure 10

Cristellaria calcar H. B. BRADY (part) (not Linné), *1884*, Rep. Voy. *Challenger*, Zoölogy, Vol. 9, p. 551, pl. 70, figs. 13, 14; FLINT (part), *1897* (*1899*), Rep. U. S. Nat. Mus., p. 318, pl. 66, fig. 1 (central figure).

Cristellaria formosa CUSHMAN, *1923*, Bull. 104, U. S. Nat. Mus., pt. 4, p. 110, pl. 29, fig. 1; pl. 30, fig. 6.

Test large, close coiled, somewhat compressed, central portion strongly umbonate, periphery with a thin keel and flattened rowel-like spines; chambers numerous, 9 to 13 in the last-formed coil; sutures distinct, limbate, of clear shell material, ending in a large, somewhat projecting boss of clear material through which the chambers of the early coils are often visible; aperture peripheral, radiate, slightly projecting.

Diameter up to 3 mm.

This is already known as a living species in the West Indian region in waters of 210 to 382 fathoms. Its occurrence as a fossil in the Miocene of Jamaica is therefore not surprising.

GENUS MARGINULINA D'ORBIGNY, 1826

MARGINULINA ACULEATA NEUGEBOREN
Plate 32, figure 11

Marginulina aculeata NEUGEBOREN, *1851*, Verh. Mitth. Siebenbürg. Ver. Nat., Jahrg. ii, p. 142, pl. 4, fig. 21.

Marginulina hispida NEUGEBOREN, 1. c., p. 142, pl. 4, fig. 22.

Marginulina pustulosa NEUGEBOREN, 1. c., p. 144, pl. 4, fig. 23.

Marginulina echinata NEUGEBOREN, 1. c., p. 143, pl. 4, fig. 25.

Test elongate, early chambers close coiled, later ones uncoiled, not compressed; sutures fairly distinct, only the later ones depressed; wall ornamented with numerous short spines, those of the later chambers blunt and often arranged somewhat in rows; aperture radiate, projecting, at one side of the terminal face.

Length up to 1.5 mm.

The above four names given by Neugeboren evidently all apply to the same species which, as is usual in this genus, shows considerable variation in the microspheric and megalospheric forms as well as in the

character of the ornamentation. This may be compared with the form figured by Silvestri as *M. hirsuta* d'Orbigny from the Pliocene of Italy.

GENUS VAGINULINA D'ORBIGNY, 1826

VAGINULINA CLAVATA COSTA
Plate 32, figure 12

Vaginulina clavata COSTA, *1855 (1857)*, Mem. Accad. Sci. Napoli, Vol. 2, p. 145, pl. 2, figs. 18*A*, *B*.

Silvestri gives figures of this species in his paper on the Pliocene of the Siena region (pl. II (VII), figs. 4, 5). The specimen figured here seems to be identical with that figured by Silvestri.

GENUS DENTALINA D'ORBIGNY, 1826

DENTALINA INORNATA D'ORBIGNY
Plate 32, figure 13

This species described from the Miocene of the Vienna Basin has also been recorded in the Miocene of Venezuela, and our specimens from Buff Bay are very similar. Our figured specimen is almost exactly identical with that figured by Costa as *Dentalina adunca* Costa from the Blue marl of the Vatican.

DENTALINA BIFURCATA D'ORBIGNY
Plate 32, figure 14

Dentalina bifurcata D'ORBIGNY, *1846*, Foram. Foss. Bass. Tert. Vienne, p. 56, pl. 2, figs. 38, 39.

D'Orbigny figured only the last two chambers of his species, but later authors have given figures showing the whole test. It seems to range from Oligocene to Pliocene in Europe. Our specimen closely resembles that of Costa from the Pliocene of Italy. The early chambers are closely set with a few costae which are added to either by splitting or the interpolation of others as later chambers are developed. The type is from the Miocene of the Vienna Basin.

GENUS NODOSARIA LAMARCK, 1812

NODOSARIA LONGISCATA D'ORBIGNY
Plate 32, figures 15, 16

Nodosaria longiscata D'ORBIGNY, *1846*, Foram. Foss. Bass. Tert. Vienne, p. 32, pl. 1, figs. 10-12.

This species with its very elongate slender chambers is very common in the Oligocene and Miocene of Europe. It occurs in the Miocene of

Venezuela and Trinidad, and the specimens from the Miocene of Buff Bay are identical with these.

NODOSARIA TETRAGONA Costa

Plate 33, figure 1

Nodosaria tetragona Costa *1855* (*1857*), Mem. Accad. Sci. Napoli, Vol. 2, p. 116, pl. 1, figs. 1*A*, *C*.

Costa described this species from the Blue marl of the Vatican, of Pliocene age. Silvestri figures it as *Frondicularia tetragona* in his work on the Pliocene of the Siena region (pl. I (VI), figs. 1-7), showing the very considerable variation that there is in the species. Our figure shows the lines of growth where the plate-like costae are added to throughout their length with each newly added chamber. Two of the costae are much broader than the others.

NODOSARIA VERTEBRALIS (Batsch)

This species has already been recorded from the Miocene of Trinidad, Venezuela and Ecuador, and is living in the West Indian region in water of moderate depths. Cushman has figured it from the Miocene of Bowden, Jamaica (Publ. 291, Carnegie Inst., Washington, 1919, pl. 7, figs. 3-5).

NODOSARIA RAPHANUS (Linné)

There are fragments of a very large species with numerous very heavy costae which may be referred to this species. They are similar to specimens from the Pliocene of Italy, and also living specimens from the Philippine region.

Explanation of Plate 33

Figs. 1.—*Nodosaria tetragona* Costa, × 30.

2.—*Nodosaria* sp. (?), × 40.

3a, b.—*Lingulina seminuda* Hantken, × 30. a, side view; b, apertural view.

4.—*Plectofrondicularia vaughani* Cushman, × 30.

5.—*Bulimina inflata* Seguenza, × 40.

6.—*Globobulimina pacifica* Cushman, × 40.

7 a, b, 8.—*Bolivina furcata* Cushman and Jarvis, n. sp., × 55. 7a, dorsal view; 7b, apertural view; 8, holotype.

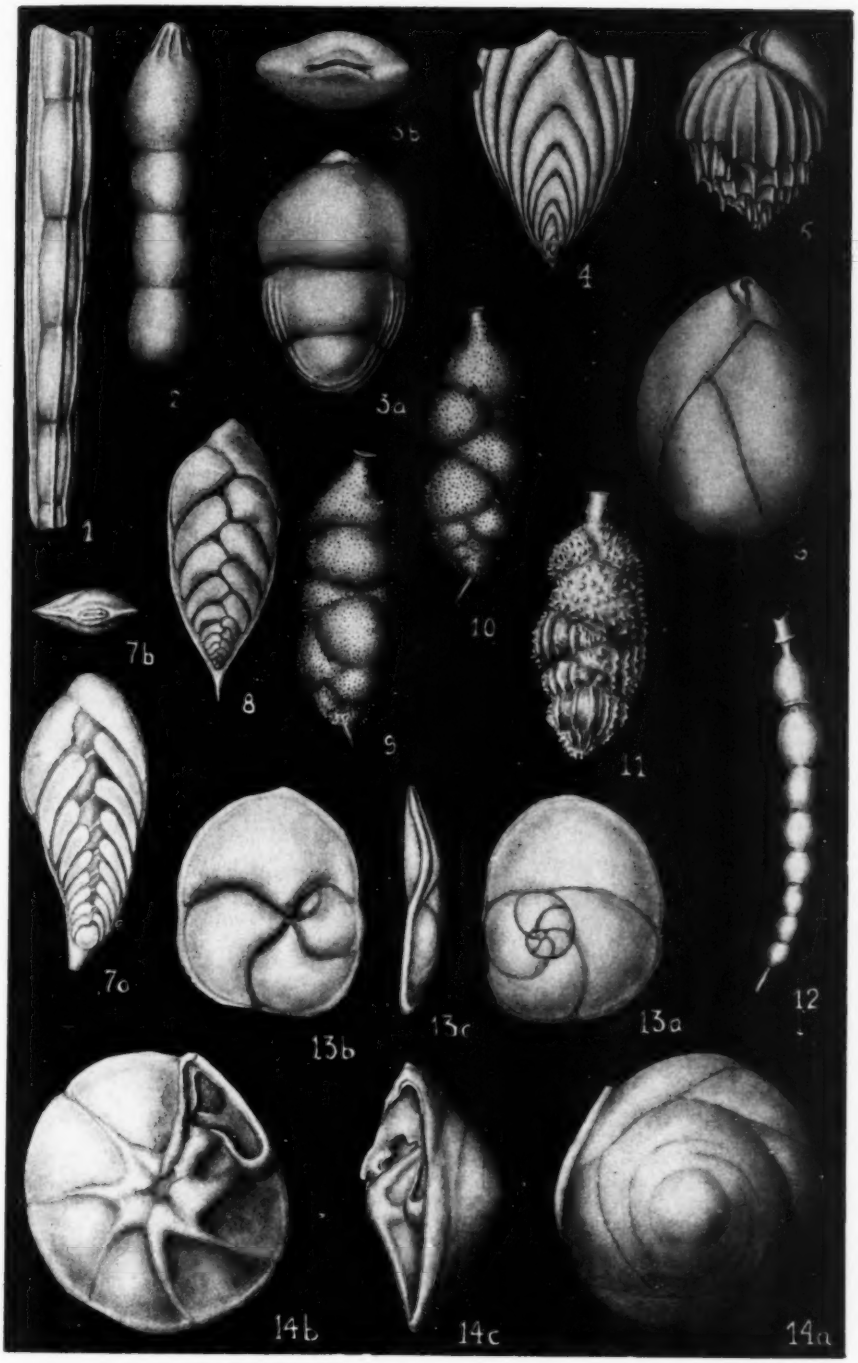
9, 10.—*Uvigerina auberiana* d'Orbigny, × 40.

11.—*Uvigerina peregrina* Cushman, var. *parvula* Cushman, × 55.

12.—*Ellipsonodosaria verneuili* (d'Orbigny), × 30.

13a-c.—*Discorbis bertheloti* (d'Orbigny), var. *floridensis* Cushman, × 35. a, dorsal view; b, ventral view; c, peripheral view.

14 a-c.—*Eponides antillarum* (d'Orbigny), × 35. a, dorsal view; b, ventral view; c, peripheral view.



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NODOSARIA SP. (?)
Plate 33, figure 2

The figured specimen consisting of the later chambers only is perhaps worthy of record in this material until complete specimens allow full identification.

GENUS LINGULINA D'ORBIGNY, 1826

LINGULINA SEMINUDA HANTKEN
Plate 33, figures 3a, b

Lingulina costata D'ORBIGNY, var. *seminuda* HANTKEN, *1875*, Mitth. Jahrb. ung. geol. Anstalt, Vol. 4, p. 41, pl. 4, figs. 8*a,b*.
Lingulina carinata D'ORBIGNY, var. *seminuda* H. B. BRADY, *1884*, Rep. Voy. *Challenger*, Zoölogy, Vol. 9, p. 518, pl. 65, figs. 14, 15; FLINT, *1897* (*1899*), Rep. U. S. Nat. Mus., p. 312, pl. 58, fig. 4.
Nodosaria carinata GOËS (not d'Orbigny), *1882*, Kongl. Svensk. Vet. Akad. Handl., Vol. 19, No. 4, p. 58, pl. 1, fig. 67 (not figs. 65, 66).
Lingulina seminuda CUSHMAN, *1923*, Bull. 104, U. S. Nat. Mus., pt. 4, p. 95, pl. 17, figs. 8, 9, 11; pl. 18, figs. 1, 2.

Test ovate, only slightly longer than broad, rapidly tapering from the subacute initial end to the greatest breadth at the last-formed chamber, compressed; chambers few, increasing rapidly in size as added, inflated, the periphery with numerous fine longitudinal costae, remainder of chamber smooth and polished; sutures very distinct, depressed, wall thick; aperture with an elongate depression, formed by two lip-like projections from the end of the test.

Length up to 2.50 mm.

There are numerous Recent records for this species, mostly from the general West Indian region in waters of medium depths. The only station from which it is recorded as abundant has a depth of 196 fathoms, and a bottom temperature of 51.6° F. With numerous records from this general region, it is not surprising to find this species in the Buff Bay material.

FAMILY HETEROHELICIDAE

GENUS PLECTOFRONDICULARIA LIEBUS, 1903

PLECTOFRONDICULARIA VAUGHANI CUSHMAN
Plate 33, figure 4

Plectofrondicularia vaughani CUSHMAN, *1927*, Contr. Cushman Lab. Foram. Res., Vol. 3, p. 112, pl. 23, fig. 3; *1927*, Jour. Pal., Vol. 1, pl. 25, fig. 11; *1929*, Contr. Cushman Lab. Foram. Res., Vol. 5, p. 92, pl. 13, figs. 21, 22.
Flabellina budensis GALLOWAY AND MORREY (not Hantken), *1929*, Bull. Amer. Pal., Vol. 15, No. 55, p. 11, pl. 1, fig. 3.

This species has already been recorded from the Miocene of Trinidad, Venezuela and Ecuador, and from the Alazan clays of Mexico. The figured specimen has an unusually pointed initial end, and the biserial chambers are very few, making it resemble typical *P. inaequalis* (Costa).

Family BULIMINIDAE

Genus BULIMINA d'Orbigny, 1826

BULIMINA INFLATA Seguenza

Plate 33, figure 5

Bulimina inflata Seguenza, *1862*, Atti Accad. Gioenia Sci. Nat., ser. 2, Vol. 18, p. 109, pl. 1, fig. 10.

Test short, ovate, triserial, composed of overlapping chambers with deep sutures; edge of chamber extending out into a free wing-like expansion with a crenulated border with short spines from which raised costae extend backward on the outer surface of the chamber, upper portions of the chambers smooth and unornamented; wall transparent and thin in the young, becoming thickened and opaque in the adult; aperture, an obliquely placed slit, elongated, widest near the upper end.

Length up to 1 mm.

The figured specimen seems to be typical and like those of the Pliocene of Italy. It occurs in the Miocene of Trinidad, Venezuela, Ecuador and Florida. In the West Indian region it also occurs in Recent dredgings. Not all of the material referred to this species in various regions is at all typical, and there are numerous very close species in this group.

Genus GLOBOBULIMINA Cushman, 1927

GLOBOBULIMINA PACIFICA Cushman

Plate 33, figure 6

Globobulimina pacifica Cushman, *1927*, Contr. Cushman Lab. Foram. Res., Vol. 3, p. 67, pl. 14, fig. 12; *1927*, Bull. Scripps Inst. Oceanography, Tech. ser., Vol. 1, p. 153, pl. 3, fig. 1; Galloway and Wissler, *1927*, Jour. Pal., Vol. 1, p. 74, pl. 11, fig. 18; Cushman, Stewart and Stewart, *1930*, Trans. San Diego Soc. Nat. Hist., Vol. 6, p. 66, pl. 5, fig. 4.

Test subglobular in the adult with the last three chambers making up the exterior by enclosing the preceding ones; sutures distinct, slightly depressed; wall very thin, finely perforate, smooth; aperture loop-shaped, with a slight border, a broad apertural tooth or plate, and an internal spiral tube.

Length up to 1.5 mm.

This species occurs in the Buff Bay material, and is probably widely distributed in the Late Tertiary as well as in the present oceans. It is common in the Pliocene of California.

GENUS BOLIVINA D'ORBIGNY, 1839

BOLIVINA FURCATA CUSHMAN AND JARVIS, N. SP.
Plate 33, figures 7, 8

Test elongate, very strongly compressed, greatest breadth formed by the last two chambers, test keeled, not serrate and ending in a large flattened spine at the initial end; chambers numerous, increasing gradually in size as added, curved and pointed at the outer end; sutures limbate, curved, very little depressed; wall smooth; aperture elongate.

Length up to 0.85 mm.; breadth 0.30 to 0.35 mm.; thickness 0.15 mm.

Holotype (Cushman Coll. No. 14,104) from Miocene clays of Buff Bay, Jamaica.

This is an interesting species with a marked difference in the character of the sutures and chambers in the megalospheric and microspheric forms, the former with the sutures much more limbate and the chambers correspondingly narrowed. The initial end has a very large flattened spine and the margin is entire. It somewhat resembles *Bolivina pisciformis* Galloway and Morrey, but has a very different outline, and the chambers are somewhat differently shaped.

GENUS UVIGERINA D'ORBIGNY, 1826

UVIGERINA AUBERIANA D'ORBIGNY
Plate 33, figures 9, 10

Uvigerina auberiana D'ORBIGNY, *1839*, in De la Sagra, Hist. Fis. Pol. Nat. Cuba, "Foraminifères," p. 106, pl. ?, figs. 23, 24.

This species has already been recorded from the Miocene of Trinidad and Venezuela. The types are from the West Indian region, where it is common in waters of medium depths.

UVIGERINA PEREGRINA CUSHMAN, VAR. PARVULA CUSHMAN
Plate 33, figure 11

Uvigerina peregrina CUSHMAN, var. *parvula* CUSHMAN, *1923*, Bull. 104, U. S. Nat. Mus., pt. 4, p. 168, pl. 42, fig. 11.

The figured specimen gives the characters of this small variety which is often abundant in waters of medium depths in the general West Indian region. Its occurrence in the Miocene of Buff Bay is its first record as a fossil in this region.

Family ELLIPSOIDINIDAE

Genus ELLIPSONODOSARIA A. Silvestri, 1900

ELLIPSONODOSARIA VERNEUILI (d'Orbigny)

Plate 33, figure 12

Dentalina verneuili d'Orbigny, *1846*, Foram. Foss. Bass. Tert. Vienne, p. 48, pl. 2, figs. 7, 8.

This very variable species is already recorded from the Miocene of Trinidad, Venezuela and Ecuador. The microspheric and megalospheric forms are very different in general appearance as Cushman has previously noted (Contr. Cushman Lab. Foram. Res., vol. 5, 1929, p. 96, pl. 14, figs. 1-3).

Family ROTALIIDAE

Genus DISCORBIS Lamarck, 1804

DISCORBIS BERTHELOTI (d'Orbigny), var. FLORIDENSIS Cushman

Plate 33, figures 13a-c

Test broad, especially in the adult, plano-convex, whole test very strongly compressed, periphery keeled; chambers 4 or 5 in the final whorl, rapidly increasing in size in the adult, broad, the last one extending to nearly half of the periphery, on the ventral side with an angular projection over the umbilical region; sutures very distinct, depressed, slightly limbate; wall smooth, finely perforate, on the dorsal side evenly perforate, on the ventral with the inner portion of each chamber clear and apparently without perforations; aperture low, elongate, at the base of the last-formed chamber.

Diameter up to slightly more than 1 mm.

This variety recently described (see Bull. 104, U. S. Nat. Mus., pt. 8) is fairly common at shallow to medium depths off the Florida coast, and probably in the entire West Indian region. This is the first record for the variety as a fossil, but the Buff Bay specimens are identical with the Recent ones.

Genus EPONIDES Montfort, 1808

EPONIDES ANTILLARUM (d'Orbigny)

Plate 33, figure 14 a-c; plate 34, figure 2

Rosalina antillarum d'Orbigny, *1839*, in De la Sagra, Hist. Fis. Pol. Nat. Cuba, "Foraminifères," p. 75, pl. 5, figs. 4-6.

Test unequally biconvex, dorsal side somewhat more convex than the ventral, periphery subacute; chambers numerous, 7 to 8 in the last-formed whorl; sutures oblique, rather indistinct and very slightly if at

all depressed on the dorsal side, nearly radiate and ending in raised areas about the umbilicus on the ventral side; wall fairly thick, finely perforate, otherwise smooth; aperture at the margin of the ventral face between the periphery and umbilicus.

Diameter up to 1 mm. or more.

This is a fairly common species living in the West Indian region, and has been referred to "*Pulvinulina schreibersii*."

Genus EPISTOMINA Terquem, 1883

EPISTOMINA ELEGANS (d'Orbigny)

Plate 34, figures 1a-c

Test biconvex, either with the sides nearly equally convex or the ventral side more strongly so, especially in the microspheric form, periphery rounded, or in small specimens more acute; chambers usually distinct, typically 7 to 9 in the megalospheric form, increasing to as many as 14 in the largest microspheric specimens; sutures distinct, limbate, but not raised, on the dorsal side strongly oblique, on the ventral side obliquely radial, ending at the center in an umbonate mass; wall finely perforate, in the thin walled specimens often showing a complex pattern of thickenings, in thick walled specimens opaque; aperture usually narrow, on the ventral side at the base of the last-formed chamber toward the periphery, with a supplementary aperture in the plane of coiling, parallel to the peripheral margin and just ventral to it, elongate.

Diameter up to 2 mm. in microspheric specimens.

A detailed synonymy of this widely distributed species is given in Part 8 of Bulletin 104, U. S. Nat. Mus., and need not be repeated here. The species is widely distributed in the Tertiary. It is most abundant in waters of considerable depth, although it is common at moderate depths off the coast of Florida adjacent to the Gulf Stream.

Family AMPHISTEGINIDAE

Genus AMPHISTEGINA d'Orbigny, 1826

AMPHISTEGINA LESSONII d'Orbigny

As in the Bowden marl, this species is common at Buff Bay, and is of large size.

Family CASSIDULINIDAE

Genus CASSIDULINA d'Orbigny, 1826

CASSIDULINA cf. SUBGLOBOSA H. B. Brady

Plate 34, figures 3a, b

The only representative of this family is the form figured here. It has the somewhat extended apertural end, characteristic of Brady's species which is fairly common living in the same general region.

Family GLOBIGERINIDAE

Genus GLOBIGERINA d'Orbigny, 1826

GLOBIGERINA sp. (?)

Plate 34, figures 5a, b

The various species of *Globigerina* are in such a chaotic state in the literature that it is difficult to identify many of them with any degree of certainty. This somewhat globular species is probably close to d'Orbigny's *Globigerina inflata*.

Genus GLOBIGERINOIDES Cushman, 1927

GLOBIGERINOIDES SACCULIFERA (H. B. Brady)

Plate 34, figure 4

This species is widely distributed in the present oceans and in Late Tertiary deposits especially those which were formed at some considerable depth. The figured specimen from Buff Bay is a characteristic one.

Explanation of Plate 34

Figs. 1 a-c.—*Epistomina elegans* (d'Orbigny), × 35. a, dorsal view; b, ventral view; c, apertural view.

2.—*Eponides antillarum* (d'Orbigny), × 30. Ventral view.

3 a, b.—*Cassidulina* cf. *subglobosa* H. B. Brady, × 40. a, side view; b, peripheral view.

4.—*Globigerinoides sacculifera* (H. B. Brady), × 40.

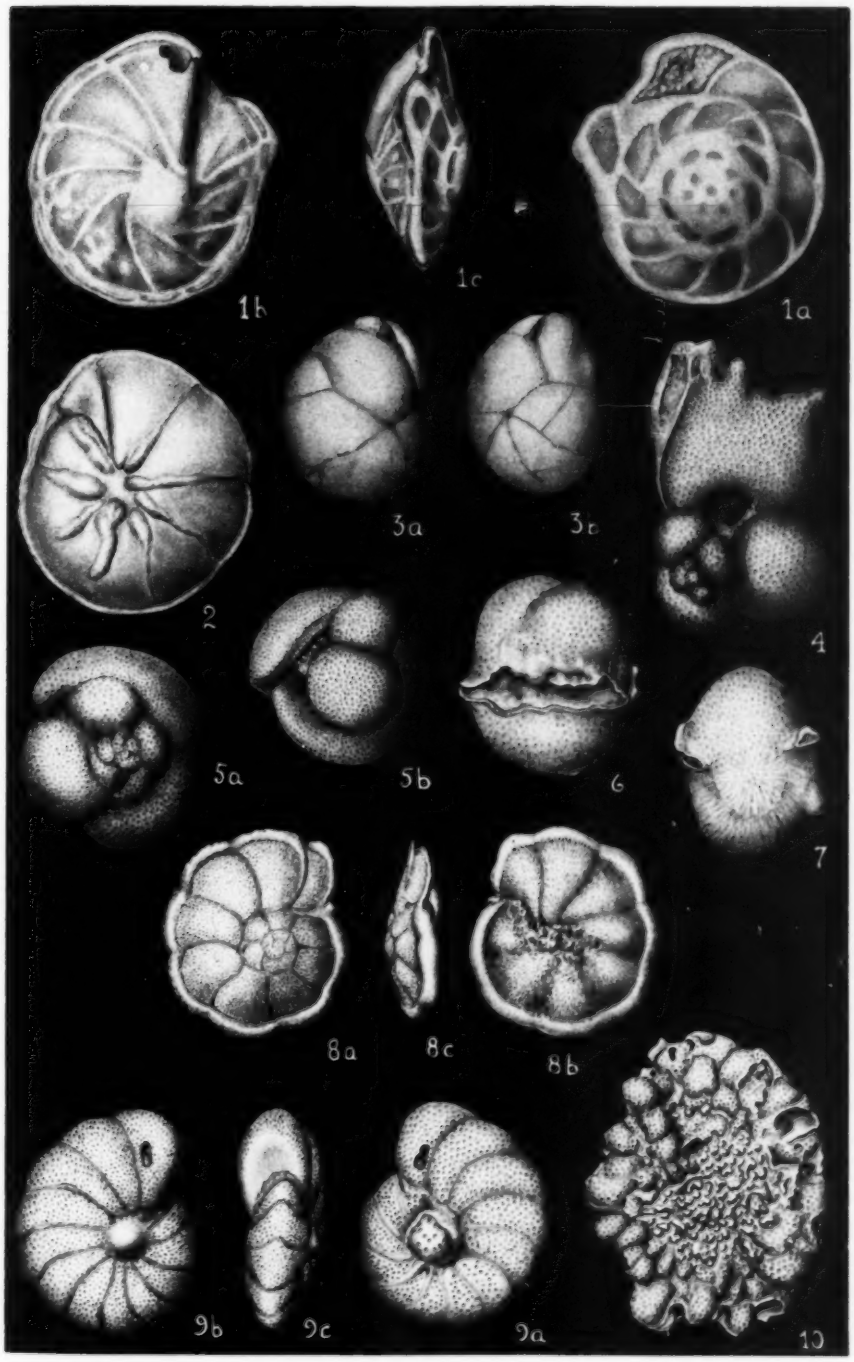
5 a, b.—*Globigerina* sp. (?), × 40. a, dorsal view; b, side view.

6, 7.—*Sphaeroidinella dehiscens* (Parker and Jones), × 40.

8 a-c.—*Globorotalia menardii* (d'Orbigny), var. *multicamerata* Cushman and Jarvis, n. var., × 35. a, dorsal view; b, ventral view; c, peripheral view.

9 a-c.—*Anomalina ornata* (Costa), × 30. a, dorsal view; b, ventral view; c, apertural view.

10.—*Planorbulinella* cf. *larvata* (Parker and Jones), × 35.



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GENUS ORBULINA D'ORBIGNY, 1826

ORBULINA UNIVERSA D'ORBIGNY

This widely distributed species occurs in some numbers in the collection from Buff Bay.

GENUS SPHAEROIDINELLA CUSHMAN, 1927

SPHAEROIDINELLA DEHISCENS (PARKER AND JONES)
Plate 34, figures 6, 7

The specimens from Buff Bay are of rather small size and perhaps less coarsely perforate than much Recent material from the West Indian region. This species seems to be very variable, and a larger series of specimens would be necessary to determine whether or not the differences are of a constant character. The occurrence of the species is indicative of moderate depths of water.

FAMILY GLOBOROTALIIDAE

GENUS GLOBOROTALIA CUSHMAN, 1927

GLOBOROTALIA MENARDII (D'ORBIGNY), VAR. MULTICAMERATA CUSHMAN AND JARVIS, N. VAR.
Plate 34, figures 8a-c

Variety differing from the typical in the larger number of chambers, more distinctly umbilical depression on the ventral side and the very heavy development of the peripheral keel.

Holotype of variety (Cushman Coll. No. 14129) from the Miocene, ½ mile E. of Buff Bay, Jamaica.

These varietal characters are constant in the specimens, and seem to apply to other Late Tertiary material, both of the West Indian region and of some parts of the Pacific.

FAMILY ANOMALINIDAE

GENUS ANOMALINA D'ORBIGNY, 1826

ANOMALINA ORNATA (COSTA)
Plate 34, figures 9a-c

Nonionina ornata COSTA, *1856*, Atti Accad. Pontaniana, Vol. 7, pt. 2, p. 203, pl. 17, figs. 17*A-C*.

Test nearly bilaterally symmetrical in peripheral view, periphery rounded, last coil somewhat evolute, dorsal side with an irregular boss, ventral side with a small central boss; chambers 10 to 12 in the adult

coil, very distinct; sutures very distinct, limbate, gently curved, very slightly if at all depressed; wall coarsely perforate; aperture at the peripheral margin, extending slightly to the dorsal side.

Our figured specimen is very close to that of Costa except that the central portion of the dorsal side is somewhat obscured by the thickened boss.

Family PLANORBULINIDAE

Genus PLANORBULINELLA Cushman, 1927

PLANORBULINELLA cf. LARVATA (Parker and Jones)

Plate 34, figure 10

The single specimen figured is the only one available from the Buff Bay material. It has many of the characters of the above species, but is somewhat irregular. It is not the thick form known from Trinidad, but is very thin, and may possibly represent a form of *Gypsina*. More material is needed to determine its full characters.

THE BRACHIOPOD GENUS PIONODEMA AND ITS HOMEOMORPHS

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ABSTRACT

The genus *Pionodema* has, of late years, been considered to embrace impunctate shells occurring in the Chazy and Black River groups. However, *Pionodema, sensu stricto*, proves actually to be a punctate shell differing from isochronous and heterochronous impunctate homeomorphs in its cardinalia and ventral musculature. The impunctate shells, here given the new generic names *Doleroides* and *Mimella*, prove to be closely allied to *Hebertella* and are placed in the new family Plectorthidae. *Pionodema*, from its structure, appears to be the forerunner of the *Schizophoria* stock. An analogous situation to that of *Pionodema* is portrayed in the British Isles by *Schizophorella*, whose genotype, *S. fallax*, has an inpunctate shell, whereas *Orthis mullochiensis*, usually considered congeneric with it, has a punctate shell and belongs to a new generic group, *Mendacella*, typified by "*Rhipidomella*" *uberis* (Billings).

During the progress of brachiopod studies at Yale University, to be a joint work with Professor Charles Schuchert, the genus *Pionodema* Foerste has been the subject of a critical investigation. The results of this research show that *Pionodema*, as now understood, actually embraces three distinct genera, which form a very remarkable illustration of brachiopod homeomorphy, the mimicry of external form being so precise in one instance that two of the genera now pass under the same *varietal* name (see pl. 35, figs. 1, 2, 5, 6).

The genotype selected by Foerste for *Pionodema* is *Orthis subaequata* Conrad, a species which occurs commonly in the Black River beds of Wisconsin and Minnesota. Hall and Clarke included this species in their genus *Dalmanella* when, in 1892, they revised and subdivided the genus *Orthis*, and its association in this group was continued by other authors until 1909, when Foerste[1] separated it from *Dalmanella* to found the new genus *Bathycoelia*. This name he later discovered to be preoccupied and substituted *Pionodema* for it.[2] Foerste merely designated *D. subaequata* as the type of the genus and stated that it typified a group ranging from the Chazy (Stones River) to the Devonian. He gave no discussion of internal anatomy, and no generic diagnosis. Since Foerste's proposal

[1]Bull. Sci. Lab. Denison Univ., Vol. 14, 1909, p. 221.

[2]Ibid., Vol. 17, 1912, p. 139.

of the name, the genus has generally been classified with the impunctate division (subfamily Plaesiomiinae) of the family Rhipidomellidae,[3] or of the family Orthidae.[4] Recently, however, Kozlowski[5] has suggested that it be placed with the punctate genus *Schizophoria* and its allies, thus indicating a divergence from the common view that the shell of *Pionodema* is impunctate.

It is not the purpose of the present paper to argue the taxonomic importance of punctation, but to show that the genus *Pionodema*, as currently understood, is composite, including both punctate and impunctate shells that differ not only in punctation but in internal shell structure as well. These are homeomorphs, both isochronous and heterochronous, which have been mistakenly referred to a single genus.

In the Black River beds of Minnesota two types of shells occur side by side (isochronous homeomorphs) which are referred ordinarily to *Pionodema*; one of these is punctate and the other is without punctation. So close is the external resemblance in two of the specimens that they have been placed under the same varietal name, ("*P.*" *subaequata gibbosa* Billings, see plate 35). There are also non-punctate shells (*P. globosa* Willard) in the Chazy (Ottosee) of Tennessee and Virginia (heterochronous homeomorphs) which are referred commonly to *Pionodema*. It will be shown that the internal shell anatomy of the punctate species differs radically from that of the impunctate homeomorphs. In the anatomical discussion below, the punctate shells will be considered first (Group A), and then the two impunctate groups (B and C).

Group A. Black River punctate shells. Inside the ventral valve of this group there are prominent teeth supported by well defined, discrete, and widely divergent dental plates, whose anterior ends are continued forward as low elevations along the lateral margins of the muscular field. The adductor track is generally more or less elevated and bears lanceolate adductor scars; the diductor scars (including the adjustor scars) are subflabellate and their front ends are extended anterior to the termination of the adductor track for a short distance but never enclose it. In front of the adductor scars there is commonly a low elevation or median ridge extended forward for a short distance. In the apex of the delthyrium there is a small plate, probably a pedicle attachment, filling the posterior of the apex flush with the area but sloping forward or bevelled at

[3]Schuchert in Zittel-Eastman, Text-book of Paleontology, Vol. 1, 1913, p. 382.

[4]Schuchert, Brachipoda, Foss. Cat., Pars 42, 1929, p. 14.

[5]Pal. Polonica, Vol. 1, 1929, pp. 53-54.

its front end, and showing concentric lines of growth. The front or bevelled portion of the plate is attached to the inner surface of the thickened delthyrial margin formed by the progressive growth-track of the teeth. Such a plate has been seen in *Schizophoria*, *Enteletes*, and a few species of dalmanellids but never in the impunctate shells discussed below. (See pl. 35, fig. 3.)

In the dorsal valve (pl. 35, fig. 4) the cardinal process, although small in size, has an expanded myophore or muscular attachment, is distinctly bilobed, and is dalmanelloid in every respect. The crural bases are long, somewhat curved, and shaped like the tusk of a boar. The crural base supports are widely divergent, discrete plates which attach directly to the valve. In one species (*P. subaequata*) their anterior ends are produced forward as low ridges which curve inward toward the median ridge. The sockets are defined by small concave plates, here termed fulcral plates. These unite the outside face of the crural base with the inside wall of the valve. The median ridge is a low elevation extending forward to the middle of the shell, dividing the adductor scars into a right and left set. The posterior adductor scars are the smaller; each scar of the anterior pair appears to be composed of two units, a larger inner scar and a smaller outer scar. This duplex character of the anterior adductors appears in many orthoid shells, especially in *Schizophoria* and *Orthotichia*. The outer, extra set may represent dorsal adjustors.

Group B. Black River impunctate shells. In this group the delthyrium is completely open; the teeth are strong, with deep crural fossettes; the muscular field is suboval and divisible into three elements, the adductor, diductor, and adjustor scars. The first are hemi-elliptical impressions situated on each side of a low median ridge; the diductor impressions are elongate, expanded in front, and do not extend anterior to the end of the adductor track; the adjustor scars are situated at the base of the dental plates and partially on their sides. The whole field is surrounded by a low elevation of adventitious shell substance. The entire inner surface of the shell is marked by low radial ridges and elongate pustules, the latter being interrupted ridges. (Pl. 35, fig. 7.)

In the dorsal valve the cardinal process is a simple, thick ridge, having a compressed myophore. The crural bases are long but blunt, their supporting plates converge, and unite beneath the cardinal process to form a shallow sessile cruralium. Concave fulcral plates are present exactly as in the punctate division. The median ridge extends to the middle of the valve and bisects a quadripartite adductor field.

Group C. Chazy impunctate shells. In the ventral valve of these shells the dental plates are discrete and are continued directly to the floor of the valve. They are bent slightly inward near their contact with the floor and mark off deep umbonal cavities. The muscular field is strongly trilobed in front; the adductor track expands in its forward growth. The diductor tracks are widely divergent and their anterior extremities extend in front of the end of the adductor track. Pallial markings are prominent. Two main trunks are given off from the anterior ends of each of the diductor impressions. Each trunk divides and sends a branch postero-laterally and one antero-medially. The former subdivides into two subsidiary trunks and the branches directed antero-medially likewise bifurcate. These bifurcations are repeated more rapidly

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EXPLANATION OF PLATE 35

(S), Schuchert Coll.; (P), Peabody Museum Coll.

FIGS. 1, 2.—*Pionodema subaequata* (Conrad), (S. 1358) holotype. 1, Ventral valve, × 1.3 Black River, Chatfield, Minn. 2, Same, dorsal view, × 1.3.

3.—*Pionodema* cf. *conradi* (N. H. Winchell). (S. 1359) × 1.3. Ventral interior, showing subflabellate diductor scars, adductor impressions, incipient ridge, and pedicle plate. Black River, St. Paul, Minn., west side.

4.—*Pionodema subaequata* (Conrad) (S. 1364) × 1.3. Dorsal interior, showing crural bases and divergent supporting plates. Black River, near Lanesboro, Minn.

5-7.—*Doleroides* cf. *gibbosus* (Billings). 5, Ventral valve (S. 507), × 1.3. This specimen and that of *Pionodema subaequata* shown in figs. 1, 2 form a very remarkable example of isochronous homeomorphy, having been previously identified as *P. subaequata gibbosa* (Billings). Black River, Chatfield, Minn. 6, Same, dorsal view, × 1.3. 7, Ventral interior of *D. gibbosus* (Billings) (S. 537), ×1. 3, showing oval outline of muscular area, short median ridge and narrow diductor impressions. Decorah shale, Minnesota.

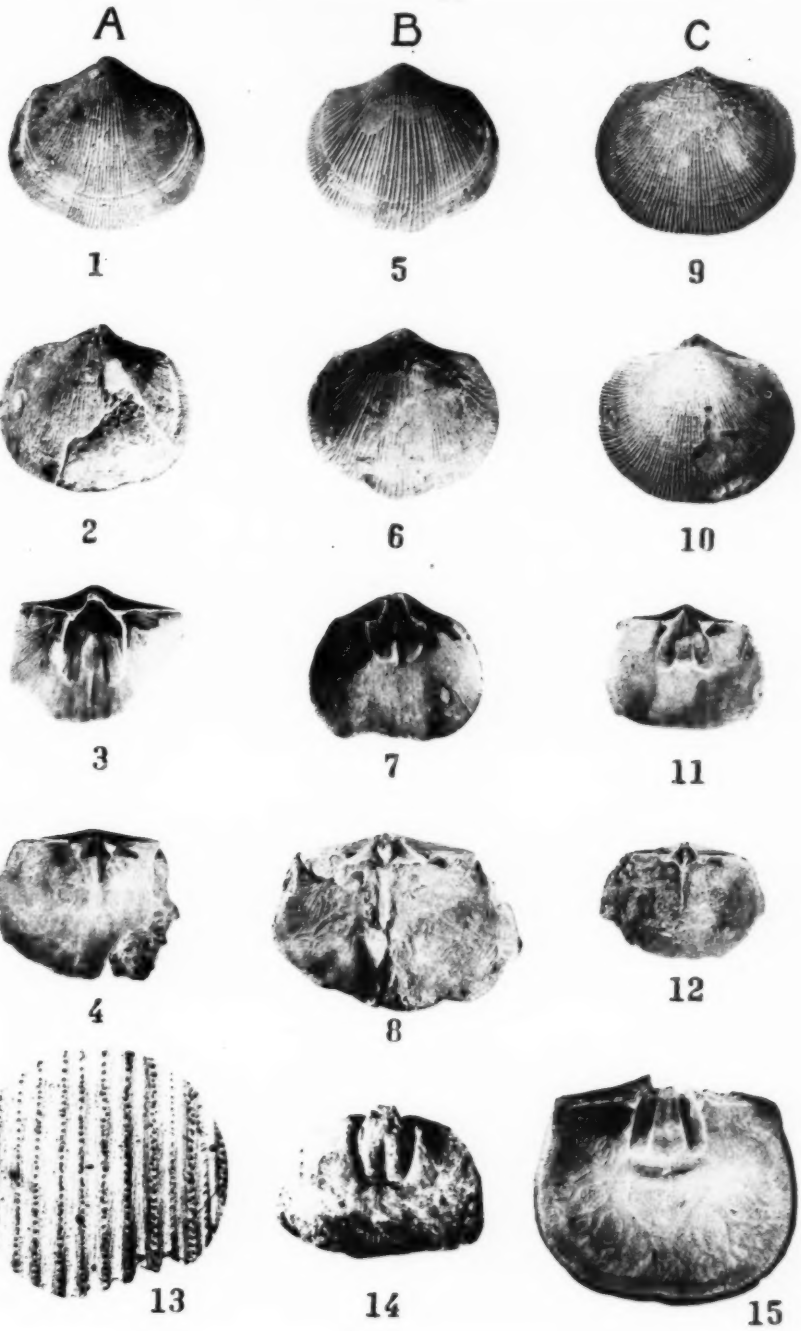
8.—*Doleroides pervetus* (Conrad). (S. 493) × 1.3. Dorsal interior. The cardinal process in this individual has become greatly thickened. For a normal cardinal process, see plate 37, fig. 13. Black River, St. Paul, Minn.

9-12.—*Mimella globosa* (Willard). 9, Ventral exterior (S. 483), × 1.3. Chazy, Luttrell, Tenn. 10, Dorsal view of the same specimen. 11, Ventral interior of another specimen, (S. 482) × 1.3, showing trilobed muscular area. Chazy, Washburn, Tenn. 12, Dorsal interior of the same specimen, × 1.3.

13.—*Pionodema* cf. *conradi* (N. H. Winchell). Thin section of shell figured on this plate, fig. 3. Circ. × 20. Photographed by L. G. Henbest.

14.—*Doleroides gibbosus* (Billings). (S. 509) × 1.3. Specimen sent to Professor Schuchert by Walter Billings. Prepared to show the *Doleroides*-type of ventral musculature. This species is the type of the new genus. Black River, Ottawa, Canada.

15.—*Mimella melonica* (Willard). (S. 474) × 1.3. Ventral interior showing pallial markings. Chazy, Luttrell, Tenn.



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until the main sinuses are broken up completely into innumerable subsidiary rami. The two inner trunks bound a central heart-shaped area. (Pl. 35, figs. 11, 15.)

The dorsal valve of this group is characterized by convergent crural base supports which form a sessile cruralium somewhat deeper than is usual in the previously discussed group. The cardinal process is thin and septum-like but has a compressed, crenulated myophore. Fulcral plates are present on the outside of the crural bases and the median ridge is thin. (Pl. 35, fig. 12.)

Summarizing the distinguishing characteristics of the three groups of shells, it is found that Group A may be identified by its punctate shell in combination with a peculiar ventral musculature, a ventral apical plate, and, in the dorsal valve, by widely divergent crural base supports and a bilobed cardinal process. In Group B the shell substance is impunctate, the ventral muscle-field is suboval and bisected in the middle by a low ridge, and in the dorsal valve the crural base supports are convergent, uniting beneath the cardinal process. In Group C the ventral muscle-field is strongly trilobed in front and there is a system of complicated pallial markings. The dorsal valve is provided with a sessile cruralium somewhat deeper than in the former group (Text fig. 1).

Several questions now present themselves: (1) Which of these groups should bear the name *Pionodema?* (2) What is the relationship of *Pionodema* to other brachiopods? (3) To what genera and family do the other two groups belong? These questions will be answered in the order given above.

(1). *Pionodema* Foerste, emend. (Group A). The name *Pionodema* is assigned here to the punctate shells for the following reasons:

(a) The external form and ventral musculature of the punctate shells agree exactly with these features in Conrad's type specimens of *O. subaequata* (Pl. 36, figs. 1, 2, 5).

(b) Hall and Clarke, and Winchell and Schuchert considered *O. subaequata* to have a punctate shell (Pl. 35, fig. 13).

FIG. 1

(c) Foerste proposed the name *Bathycoelia* (later *Pionodema*) as a subgeneric designation under the genus *Dalmanella* and thereby implied that *Pionodema* has a punctate shell substance.

The writer is therefore placing the following species, all of which are punctate, under the generic heading of *Pionodema*: *Orthis bellula* Meek, *O. subaequata* Conrad, *O. subaequata circularis* Winchell, *O. subaequata conradi* Winchell, *Pionodema uniplicata* Cooper and *P. minnesotensis* Cooper, n. spp.

A study of the Conrad types (see following) is not wholly satisfactory in determining the shell structure of *Pionodema*, since all of the specimens are silicified. However, a free ventral valve in the lot has musculature identical with that of the punctate shells referred here to *Pionodema*. This fact, together with the statements of Hall and Clarke and of Winchell and Schuchert, is sufficient evidence for considering that the genus consists of punctate shells. The final proof, of course, would be a section across the beaks of the type, which should show divergent crural bases if the shell were actually punctate before silicification.[6]

(2) Once it is granted that the shell structure of *Pionodema* is punctate, it becomes easier to establish the taxonomic position of the genus in the brachiopod phylum, as the earliest representative of the Schizophoriidae. The connecting link between *Pionodema* and *Schizophoria* is the Silurian species *S. senecta* (Hall). The latter presents many striking similarities to members of the earlier genus, especially in the ventral musculature, which has subflabellate diductor scars separated by a narrow, tapering median ridge that is continued for some distance forward of the front end of the muscular field. The part of this ridge bearing the adductor scars is the incipient septum which becomes so prominent later in the Carboniferous members of the Schizophoriidae such as *Orthotichia* and *Enteletes*. In the dorsal valve the resemblance of structure to that of *Pionodema* is still more striking. In both genera, and also in *Orthotichia* and *Enteletes*, the crural bases are curved plates suggesting the tusk of a boar, the crural base supports are widely divergent, and there is a small fulcral plate uniting the crural base supports to the inner wall of the shell. The structure of the cardinalia of each member of the Schizophoriidae is the same, and no better criterion of family relationship could be found than this structural ensemble (Pl. 37, figs. 4-10).

[6]Fenton, in a recent paper on Plattin fossils (Am. Midland Nat., Vol. 11, pts. 3-4, 1928, pp. 132-35, pl. 3, figs. 13-19), has figured the ventral musculature of *P. subaequata* and "*P.*" *perveta*, showing the subflabellate outline of the former and the oval plan of the latter. He does not, however, indicate the shell structure of the two groups because his specimens also were silicified.

Schuchert observed the external resemblance of *Pionodema* to *Schizophoria* in 1913[7] when he characterized the former as follows: "Resemble small *Schizophoria* but are impunctate." It was Kozloswki, however, who first suggested the actual relationship, but he failed to determine the shell structure of *Pionodema*, although he did question Schuchert's assertion that the genus has an impunctate shell. The writer's conclusions, which are completely in accord with Kozlowski's suggestions, were presented at the 1929 meeting of the Paleontological Society in Washington, D. C., before the latter's paper appeared in this country. The confirmation of Kozlowski's ideas by the actual evidence presented independently in Washington and here makes the conclusions all the more striking.

(3) *Doleroides*, n. subg. of *Hebertella* (Group B). It is evident from the internal structure of the impunctate "*Pionodema*" from the Black River that it is very closely related to *Hebertella*. Externally it differs from the latter in its biconvex profile and multicostellate surface. Internally the ventral musculature differs in lacking the double-ridged adductor track and in having the diductor scars less expanded toward the front. The dorsal valves of the two are essentially the same in structure. For these finely ribbed, biconvex, pionodemoid shells the subgeneric term *Do'eroides* is suggested,[8] with *Orthis gibbosa* Billings 1857 as the type (Pl. 35, figs. 5-7, 14). An additional referred species is *O. perveta* Conrad.

The *Hebertella*-stock forms a remarkable parallelism with the *Pionodema-Schizophoria* line. *Doleroides* is homeomorphic with *Pionodema*, and the homeomorphy is carried so closely that the former group has an abundance of hollow costellae exactly as seen in *Pionodema*. The latter represents the early biconvex or lenticular phase in the evolution of *Schizophoria; Doleroides*, on the other hand, represents a biconvex stage in the development of the Hebertellas. *Schizophoria* and *Hebertella*, which are nearly identical externally in some of the species, represent the convexi-concave or reversed phase. Here, too, hollow ribs were retained in both stocks. The *Hebertella* evolution was the more accelerated and the stock died out just before the close of the Ordovician, but the more vital line of punctate *Pionodema-Schizophoria*, together with certain dalmanellids and *Rhipidomella*, persisted until the close of the Paleozoic.

Mimella, n. g. (Group C). The third group of shells, those from the Chazy of Tennessee and Virginia, likewise are related to *Hebertella* by

[7]Zittel-Eastman Text-book of Paleontology, Vol. 1, 1913, p. 382.

[8]Greek *doleros*, deceitful.

the structure of their dorsal valves. However, this group is considered to be a new genus characterized by its external resemblance to *Pionodema*, its strongly trilobate muscle-field, and its unique pallial markings. For this new genus the name *Mimella* is proposed, in allusion to its mimicry of the external form of *Pionodema*. The genotype selected to represent this group is *P. globosa* Willard 1928 (Pl. 35, figs. 9-12). Other species are *P. minuscula* Willard, *Hebertella melonica* Willard, and *H. imperator* (Billings).

Plectorthidae Schuchert and Cooper,[9] n. fam. In seeking the family relationships of the Orthacea, use has been made chiefly of the cardinalia, as has recently been done by B. B. Bancroft.[10] On this basis, it has been shown that *Pionodema*, *Schizophoria* and *Enteletes* from a clearly de-

[9]In rounding out this paper the author finds it necessary to use this family name, one taken out of a comprehensive study of the Orthacea by Schuchert and Cooper to be published during the year 1931.

[10]The Harknessellinae, Mem. and Proc. Manchester Lit. and Philos. Soc., 1928.

EXPLANATION OF PLATE 36

1, 3.—*Pionodema subaequata* (Conrad). (Am. Mus. Nat. Hist., Cat. No. 910) × 1.3. Ventral and dorsal views respectively of the holotype. Black River, Mineral Point, Wis.

4, 7.—*Doleroides pervetus* (Conrad). (Am. Mus. Nat. Hist., Cat. No. 694–3) × 1.3. Ventral and dorsal views of the lectotype. Black River, Mineral Point, Wis.

5.—*Pionodema* cf. *subaequata* (Conrad). (Am. Mus. Nat. Hist., Cat. No. 694–3), × 1.3. Dorsal view. This specimen is labelled *Orthis perveta* Conrad and is in the type lot of that species. The diverging crural base supports prove it to be a *Pionodema*. Black River, Mineral Point, Wis.

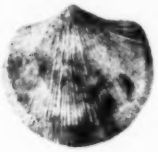
6, 9.—*Mendacella mullochiensis* (Davidson). 6, Dorsal internal mold (Mrs. Robert Gray Coll., British Mus., Geol. Dept., Cat. No. B. 44596), × 1.3. Lower Llandovery, Mulloch Hill group, Mulloch Hill, Girvan, Ayrshire. 9, Ventral internal mold (British Mus., Geol. Dept., Cat. No. B 44610), × 1.3. Same locality as fig. 6.

2, 16, 17, 18.—*Mendacella uberis* (Billings). (P. 10415) × 2. Ordovician, Ellis Bay, ½ mile east of Junction Cliff, Anticosti. 2, Ventral exterior. 16, Ventral interior, × 2. 17, Internal mold of ventral valve, × 2. 18, Dorsal interior, × 2.

8, 11.—*Schizophoria* cf. *senecta* Hall. (P.) × 1.3. Dorsal and ventral internal molds showing close resemblance of cardinalia and ventral musculature to those of *Pionodema*. Silurian, Port Daniel, Quebec.

10,12,13,15.—*Schizophorella fallax* (Salter). Upper Bala, Drummock Group, Thraive Glen, Girvan, Ayrshire. 10, Internal mold of the ventral valve. (British Mus., Geol. Dept., Cat. No. B. 52133.) × 1.3. 12, Wax impression of the dorsal exterior. (British Mus., Geol. Dept., Cat. No. B. 52123) × 1.3. 13, Wax impression of ventral exterior, (Mrs. Robert Gray Coll., British Mus., Geol. Dept., Cat. No. B. 52121) × 1.3. 15, Internal mold of the dorsal valve (British Mus. Geol., Dept. Cat., No. B. 44610) × 1.3.

14.—*Pionodema minnesotensis* Cooper, n. sp. (S. 1356) × 1.3. Holotype, dorsal view. Black River, Minneapolis, Minn.



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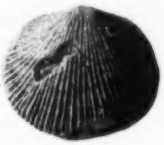

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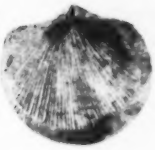

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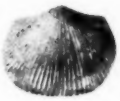

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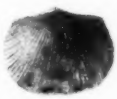

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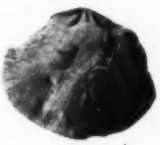

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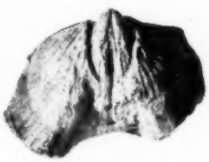

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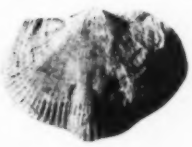

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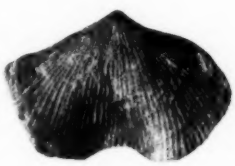

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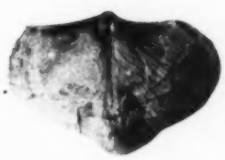

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fined family, the Schizophoriidae Schuchert, 1929. The same holds true for the two groups of impunctate shells usually identified as *Pionodema* and now separated as *Doleroides*, n. subg., and *Mimella*, n. g., which ally themselves to the new family Plectorthidae, created to receive such shells as *Plectorthis*, *Hebertella*, and *Platystrophia*. Here the crural base supports converge and unite beneath a simple cardinal process, the crural bases are blunt, and are attached to the walls of the valve by concave fulcral plates (Pl. 37, figs. 11, 13-15). This type of structure definitely excludes from association with *Hebertella* such shells as *Eridorthis* and *Glyptorthis*, which are usually incorrectly placed as subgenera of *Hebertella*. These genera do not have any crural base supports other than the swelling of adventitious shell substance under the cardinal process and crural bases, and they lack fulcral plates such as are common in *Plectorthis* and *Platystrophia*. *Eridorthis* and *Glyptorthis* are therefore most closely allied to the *Orthis tricenaria* and *O. flabellites* group.

Plectorthis, which gives the name to the family, has no relation to *Orthis sensu stricto*, and differs from it more fundamentally than in its biconvexity. It is, however, structurally the simplest member of the Plectorthidae. The young of *Hebertella* and *Platystrophia* have a very striking resemblance to *Plectorthis* and may actually be mistaken for that genus. The relationship of *Platystrophia* to *Plectorthis* and *Hebertella* has been overlooked because in maturity the mantle of the former deposits great quantities of testaceous material on the inside of the valve, filling the umbonal cavities marked off by the crural base supports and fulcral plates, totally obliterating the latter as discrete plates.

Schizophorella Reed and *Mendacella* Cooper, n. g. It is fitting to include here a brief discussion of the genus *Schizophorella* Reed, which resembles *Pionodema* externally and, like the latter, is a composite genus. The group was named because of its superficial similarity to *Schizophoria*. Its author assigned to it two species, *Orthis fallax* Salter (Pl. 36, figs. 10, 13, 12, 15), the genotype, from the Drummock group of the upper Ordovician, and *O. mullochiensis* Davidson (Pl. 36, figs. 6, 9) from the Mulloch Hill group of the Lower Silurian. Through the courtesy of the British Museum the present writer has been able to study an excellent suite of each species. *S. fallax* occurs as molds of the interior and exterior, but the specimens of *S. mullochiensis* retain much of the shell substance. Fortunately, three of the specimens of *S. fallax* preserve portions of the test, which proves to be impunctate; the shell substance of the other species is punctate. As in *Pionodema*, the internal structures

of the punctate and impunctate shells are totally unlike, having differences of generic value. *S. fallax* appears to have no representatives in American Ordovician strata, but *S. mullochiensis* allies itself to a new generic group typified by "*Rhipidomella*" *uberis* (Billings), for which the generic name *Mendacella* is now proposed (Pl. 36, figs. 16-18; see also below).

SYSTEMATIC DESCRIPTIONS

FAMILY SCHIZOPHORIIDAE SCHUCHERT, 1929

GENUS PIONODEMA FOERSTE, 1912, EMEND. COOPER

PIONODEMA SUBAEQUATA (CONRAD)

Plate 35, figure 4; plate 36, figures 1, 3; plate 37, figure 6

The type of the species, which now must be regarded as the type of the genus as well, is preserved in the American Museum of Natural History, New York City. In the lot, bearing the catalogue number 910, there are four specimens; one is too imperfect to preserve its identity, and another proves to belong to the new subgenus *Doleroides*. Of the two remaining individuals, one is the free, silicified ventral valve already mentioned, and the other is the shell figured by Hall[11] as Conrad's type. This specimen must be regarded now as the type of the genus, to which reference must be made in all questions concerning the characteristics of *Pionodema*. It is a small shell, measuring 16.5 mm. in width, 14.5 mm. in length, and 9 mm. in thickness. On the dorsal valve a median sulcus extends for about one-half the length, after which it is lost in the general convexity of the shell. There is a corresponding fold on the ventral valve. Swollen ribs are most prominent on the ventral valve, where they are concentrated in the mid-region.

Specimens conforming to the type species *sensu stricto* are common in the Decorah of Missouri but are rather rare in Miinnesota. It is interesting to note that *Pionodema* has hitherto been reported from Europe only doubtfully. Raymond[12] has referred *Orthis girvanensis* to the genus but without knowledge of the interior. However, *O. redux* Barrande has essentially the same internal structure as Pionodema, but since the species occurs chiefly as internal and external molds, knowledge of the shell substance is lacking.

[11]Pal. N. Y., Vol. 1, pl. 32, fig. 2.

[12]Bull. Mus. Comp. Zoöl., Vol. 68, No. 6, 1928, p. 308.

PIONODEMA UNIPLICATA COOPER, N. SP.
Plate 35, figures 1, 2

Orthis (*Dalmanella*) *subaequata* var. *gibbosa* Winchell and Schuchert, *1895*, Geol. Minnesota, Vol. 3, pt. 1, pl. 33, figs. 43-45, (not O. *gibbosa* Billings, *1857*).

Hinge-line narrower than the greatest width of the shell, which is in the middle. Dorsal valve with convexity greater than that of the ventral valve, most convex at the middle; with a prominent fold defined only in the front half of the shell. Surface marked by costellae (fine radiating ribs) numbering about 5 to a millimeter at the front margin. Ribs of the ventral sulcus larger than elsewhere, and hollow. Smaller hollow ribs occur sporadically. Holotype measuring 20 mm. in width, 18 mm. in length, and 11.5 mm. in thickness. Width of hinge-line, 13 mm.

This species differs from *P. subaequata* chiefly in the possession of a prominent fold and sulcus at the front of the shell, a more convex ventral valve, and a more inflated umbo. The hinge-line is also proportionally shorter.

The specimen figured by Winchell and Schuchert under the name *Dalmanella subaequata gibbosa* is in the Schuchert Collection and proves to have a punctate shell. Since the *Orthis gibbosa* Billings from the Black River is impunctate, the writer has restricted this name to the impunctate shells and here proposes *P. uniplicata* for the punctate species. These two species when closely compared differ also in details of the exterior and therefore can be separated on other criteria than punctae.

P. uniplicata occurs in the Black River beds of Minnesota.

PIONODEMA MINNESOTENSIS COOPER, N. SP.
Plate 36, figure 14

Orthis (*Dalmanella*) *subaequata* Winchell and Schuchert, *1895*, Geol. Minnesota, Vol. 3, pt. 1, pl. 33, figs. 33, 34,(not *O. subaequata* Conrad, 1843).

The shell figured by Winchell and Schuchert does not conform with a strict interpretation of the type species of the genus. Its chief points of departure are in the proportionally wider hinge-line, broader area, line of greatest width situated just in front of the hinge-line, and dorsal fold extending beyond the middle of the valve. Furthermore, *P. minnesotensis* is proportionally not so thick as typical specimens of *P. subaequata*. It occurs in the Black River beds of Minnesota.

FAMILY DALMANELLIDAE SCHUCHERT, 1929

GENUS MENDACELLA COOPER, N. G.

Plate 36, figures 2, 16-18

Externally like *Rhipidomella* but internally like *Dalmanella* (*sensu lato*). Shells subcircular; hinge-line straight, narrower than the greatest width of the valves; cardinal extremities rounded; lateral profile subequally biconvex. Dorsal valve with a faint sulcus at the posterior, but becoming obsolete near the middle of the valves. Ventral area shorter than the dorsal, delthyrium open. Surface multicostellate; shell substance punctate.

EXPLANATION OF PLATE 37

FIGS. 1,3,13.—*Doleroides pervetus* (Conrad). 1, Ventral view of large adult specimen, (S. 498) × 1.3. Black River, Lanesboro, Minn. 3, Same, dorsal view, × 1.3. 13, Dorsal interior of small specimen. (S. 499) × 1.3. Black River, Fountain, Minn.

2.—*Doleroides gibbosus* (Billings). Exterior of ventral valve figured on Plate 35, fig. 7, × 1.3. Decorah shale, Minnesota.

4, 7.—*Enteletes* sp. (S. 1501) × 1.3. Showing curved crural bases and divergent supporting plates. Compare figs. 5, 6, 11, 14, 15. Wolfcamp, West Texas. 7, Same turned to the side to show fulcral plate and curved crural bases.

5, 8.—*Schizophoria iowensis* (Hall). (S. 1441) × 1.3. 5, Dorsal interior, showing divergent crural base supports and fulcral plates. Upper Devonian, Rockford, Iowa. 8, Same turned to show fulcral plate, × 1.3.

6.—*Pionodema subaequata* (Conrad). (S. 1316) × 1.3. Dorsal interior, showing crural bases and divergent supporting plates. Black River; near Lanesboro, Minn.

9.—*Pionodema circularis* (N. H. Winchell). (S. 1348) × 2. Interior of dorsal valve seen from the side, and showing fulcral plate. Compare with figs. 7 and 8. Black River, High Bridge, Kentucky.

10.—*Pionodema* cf. *circularis* (Winchell). (S. 1360) × 1.3. Dorsal interior showing widely flaring crural plates. Glade, Lebanon, Kentucky.

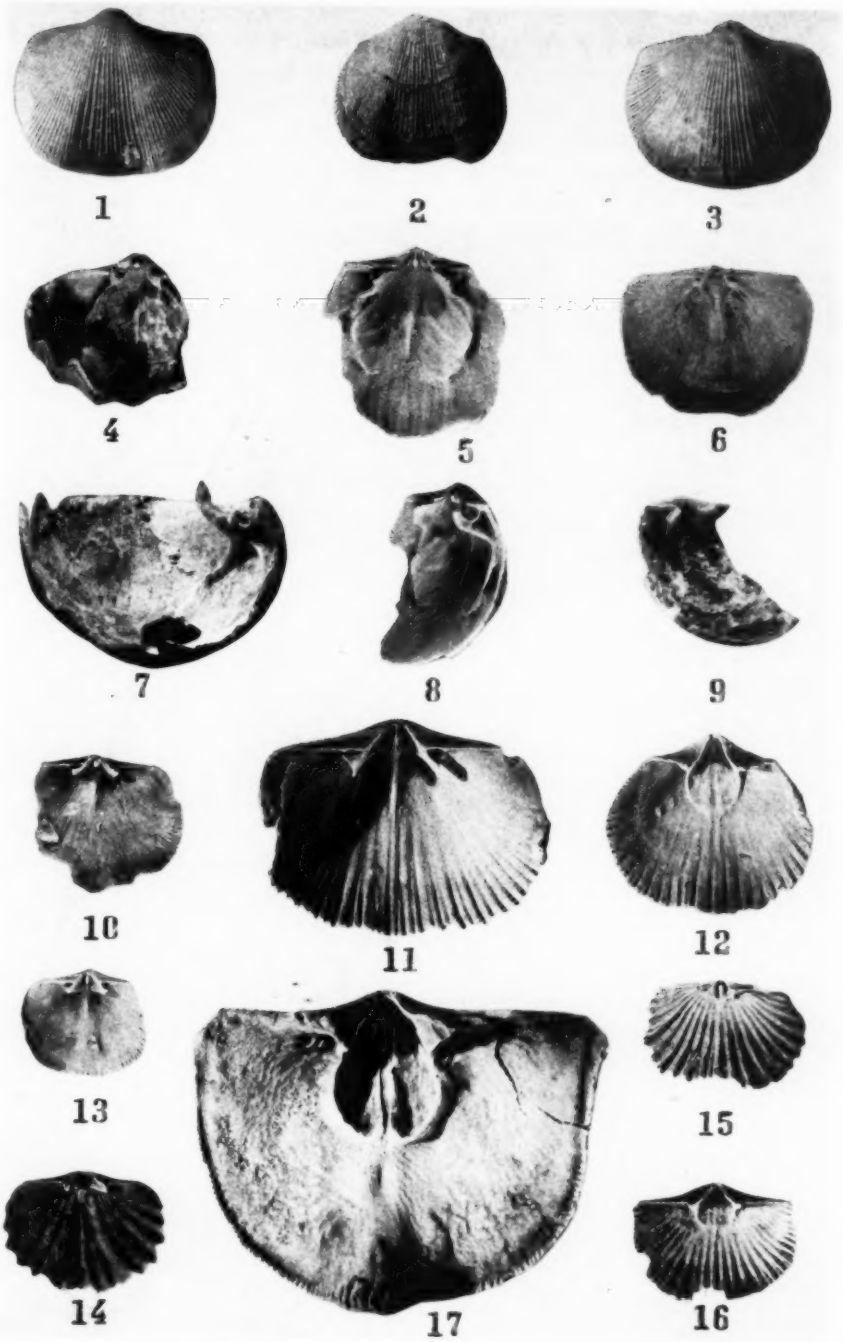
11, 17.—*Hebertella occidentalis sinuata* (Hall). Dorsal interior, showing convergent crural base supports, simple cardinal process, and fulcral plates. (S. 451) × 1.3. Compare this type of cardinalia with that of *Pionodema* and *Schizophoria*. Maysville, Cincinnati, Ohio. 17, Ventral interior, showing musculature. (S. 397) × 1.3. Maysville, Cincinnati, Ohio.

12.—*Hebertella frankfortensis* Foerste. (S. 440) × 1.3. Ventral interior showing characteristic musculature. Trenton, Frankfort, Kentucky.

14.—*Platystrophia laticosta* (Meek). (S. 575) × 1.3. Dorsal interior of a young specimen, showing convergent crural bases. Note resemblance to *Plectorthis*, fig. 8. Maysville, Cincinnati, Ohio.

15.—*Plectorthis plicatella* (Hall). (S. 298) × 1.3. Dorsal interior, showing convergent crural base supports. Maysville, Cincinnati, Ohio.

16.—*Plectorthis jamesi* (Hall). (S. 316) × 1.3. Ventral interior, showing close similarity to Hebertella. Maysville (Corryville), Cincinnati, Ohio.



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Ventral interior. Delthyrial cavity shallow, teeth strong; dental plates thick and strong; muscular area bilobed; diductor impressions long and narrow, extended in front of the small adductor impressions, which together form an oval impression. Diductor scars may or may not be separated by a low ridge. Adjustors visible at the base of the dental plates.

Dorsal interior. Crural bases long, slightly divergent, bluntly pointed. Crural base supports short, concave fulcral plate present. Cardinal process small, with a short shaft and a small, bilobed myophore or muscular attachment. Median ridge wide, extending to middle of the valve, and dividing the adductor impressions. Posterior scars smaller than the anterior pair.

Genotype *Orthis uberis* Billings 1866, from the upper Ordovician (Ellis Bay), one-half mile east of Junction Cliff, Anticosti. Two of the type specimens are figured by Twenhofel in his *Geology of Anticosti* (Mem. 154, Geol. Surv. Canada, 1927 1928, pl. 17, figs. 12,13). Other species referred to *Mendacella* are *Orthis mullochiensis* Davidson and *Schizophorella arisaigensis* McLearn.

Family PLECTORTHIDAE Schuchert and Cooper, n. fam.

Subgenus DOLEROIDES Cooper, n. subg.

DOLEROIDES PERVETUS (Conrad)

Plate 35, figure 8; plate 36, figures 4, 7; plate 37, figures 1, 3

It is important to make a note concerning the type of this species. Conrad's types are in the American Museum of Natural History, New York, and were loaned to the writer by Dr. Chester A. Reeds. In the type lot are two specimens bearing the catalogue number 694–3. One specimen is that figured by Hall[14] (our Pl. 36, fig. 1), and the other is smaller (Pl. 36, fig. 2). The dorsal valve of the latter is so eroded that the track of the crural base supports is clearly visible. They are widely divergent and show the specimen to be a true *Pionodema*. The other specimen is impunctate as far as can be determined, and, since Hall figured it as *O. perveta*, it should be regarded as the holotype of the species. This specimen is evidently a young individual of larger forms referred commonly to *O. perveta*. The larger specimens agree with the type in being decidedly transverse and in possessing a shallow sulcus on the dorsal valve in young stages.

[13] *Mendax*, lying.

[14] Pal. N. Y., Vol. 1, pl. 32, fig. 5.

DOLEROIDES GIBBOSUS (BILLINGS)
Plate 35, figures 5, 7, 14; plate 36, figure 2

Winchell and Schuchert[15] state that "Walter Billings has kindly presented to one of the writers (Schuchert) specimens of *O. gibbosa* from Black River limestone near Ottawa." These specimens, which are in the Schuchert Collection, are impunctate shells and have the musculature characteristic of the new genus. The punctate shells referred by Winchell and Schuchert to this "variety" have been designated as *Pionodema uniplicata* Cooper, n. sp. There is also an impunctate homeomorph of *P. uniplicata* which is identical with Billings' species (see pl. 35, figs. 5-6).

To obviate any misinterpretation as regards the type of the new genus *Doleroides*, the specimens figured on Plate 35, figures 7 and 14, and specimen 5.508 from the Black River of Fountain, Minnesota, not figured here, are hereby designated as the types.

GENUS MIMELLA COOPER, N. G.

The specimens figured on Plate 1, figures 9-12 are the types of the new genus.

[15]Geol. Minnesota, Vol. 3, pt. 1, p. 451.

A NEW AMMONOID FAUNA OF LATE PALEOZOIC AGE FROM WESTERN TEXAS

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ABSTRACT

The gap between the complex ammonoids of the Permian and the relatively simple ones of the Pennsylvanian has recently been bridged in part by the ammonoids described from the basal part of the Wolfcamp formation (zone of Uddenites) of western Texas, and those described in this paper fill much of the remainder. These ammonoids come from the upper part of the Gaptank formation. It is concluded that they are of late Pennsylvanian age and distinctly, but not markedly, older than those of the lower Wolfcamp. The fauna contains relatively few fossils other than cephalopods, and most of the latter are new but are closely related to known forms. One new genus, *Prouddenites*, and four known and seven new species of ammonoids are described, and a description of a new species of *Orthoceras* is included.

In the late Paleozoic the ammonoids underwent rather rapid evolution, and for the most part those known from the Permian are much more highly specialized than those of the Pennsylvanian. The gap between typical Pennsylvanian and typical Permian ammonoids has recently been bridged in part by Böse[1] and J. P. Smith,[2] who have described a transitional fauna from the lowest Permian, the so-called "zone of *Uddenites*" at the base of the Wolfcamp formation; and it seems to the writer that most of the remainder of the gap is closed by the ammonoids described in the following pages, which came from the highest Pennsylvanian, the upper part of the Gaptank formation.

Most of these ammonoids were collected by Philip B. King and Robert E. King during their recent work on the Pennsylvanian and Permian of the Glass Mountains of western Texas, and the rest were obtained later by Philip B. King and C. L. Baker. All were deposited in Peabody Museum of Natural History, Yale University, and were made available for study by the writer by Prof. C. O. Dunbar, Dr. E. H. Sellards, and the collectors. The writer is also indebted to Prof. Dunbar for continued interest and advice during the preparation of this report.

The occurrence of this ammonoid fauna is being described by Dr. Philip King, and it will suffice here to state that all of the ammonoids

[1]Böse, Emil, The Permo-Carboniferous ammonoids of the Glass Mountains, west Texas, and their stratigraphical significance: Univ. Texas Bull. 1762, 1917 (1919).

[2]Smith, J. P., The transitional Permian ammonoid fauna of Texas: Am. Jour. Sci., 5th series, Vol. 17, pp. 63-80, 1929.

described in this report appear to be from the same zone in the uppermost part of the Gaptank formation. Although the ammonoids are well preserved and exceedingly abundant, other fossils are few and for the most part too fragmentary for specific identification. However, *Triticites* sp., *Composita subtilita*, *Linoproductus* sp., *Marginifera* sp., *Pustula* sp., *Worthenia?* sp., and undeterminable fragments of brachiopods, pelecypods, and gastropods have been recognized, and the collections contain two fragmentary specimens that appear to represent large *Domatoceras*-like nautiloids, but are too incomplete to merit detailed description.

The ammonoids are very closely related to those of the basal part of the Wolfcamp formation, i. e., the zone of *Uddenites*, but are distinctly older and are clearly intermediate between them and those known from the Upper Pennsylvanian (Cisco, Emporia, Abo?, etc.). Only two species, *Daraelites texanus* and *Uddenites schucherti*, are known to occur in both this fauna and the zone of *Uddenites*, but of the 10 ammonoid genera known to be represented in the former, the following 7 are represented also in the latter: *Gastrioceras*, *Paralegoceras*, *Schistoceras*, *Marathonites*, *Prothalassoceras*, *Daraelites*, and *Uddenites*. The fact that this fauna is older than that of the zone of *Uddenites* is indicated by the occurrence in it of *Bactrites*, a new genus called *Prouddenites*, and *Pronorites;* the first has not been recognized previously above the Lower Pennsylvanian, and the last two are directly ancestral to *Uddenites* and *Parapronorites*, respectively, of the basal Wolfcamp. The occurrence of *Uddenites* in this Gaptank fauna does not mean that the fauna is of the same age as that of the zone in which *Uddenites* is so common, for the localities in which the two faunas occur are only about 18 miles apart, and most of the elements are specifically distinct. Furthermore, it has been stated by Scott and Plummer[3] that *Uddenites* ranges well down into the Upper Pennsylvanian (Cisco) in north-central Texas.

All of the genera represented in this fauna except *Bactrites*, *Prothalassoceras*, and *Prouddenites* are known to occur in both the Pennsylvanian and the Permian; *Bactrites* has not been recognized above the Pennsylvanian, *Prothalassoceras*[4] has not been described from below the

[3]Scott, G., and Plummer, F. B., Forty-second annual meeting of the Geol. Soc. Am., December, 1929.

[4]Scott, G., and Plummer, F. B. (Geol. Soc. Am., Preliminary list of titles and abstracts of papers to be offered at the forty-second annual meeting, Washington, D. C., p. 27, 1929) mention the occurrence of a new species of *Prothalassoceras* (*P. texanum*) in the Pennsylvanian of north-central Texas, but a description of that form has not yet been published.

Lower Permian (zone of *Uddenites*), and *Prouddenites* is intermediate between *Pronorites* of the Pennsylvanian (and Permian) and *Uddenites* of the Lower Permian. This fauna then contains both Upper Pennsylvanian and Lower Permian elements and appears to be intermediate in age. However, it is distinctly older (though not markedly so) than that of the zone of *Uddenites;* Keyte, Blanchard, and Baldwin[5] and Schmidt[6] have contended that the latter is of Upper Pennsylvanian age, but Böse,[7] King and King,[8] and J. P. Smith[9] have concluded that it should be regarded as the base of the Permian.

Inasmuch as the fauna studied by the writer and that of the zone of *Uddenites* are intermediate between definite Pennsylvanian and definite Permian faunas, they are more or less equivocal, and it seems to the writer that in this case the field relationships are the best basis for correlation. King and King[10] have shown that the Gaptank (including near its top the zone of *Prouddenites*) is separated from the overlying Wolfcamp (including at its base the zone of *Uddenites*) by a very distinct unconformity. Therefore, in spite of the obvious similarity of the ammonoids of these two zones, it seems logical to regard the former as of uppermost Pennsylvanian age and the latter of lowermost Permian.

J. P. Smith[11] has already pointed out that the development of the highly complex ammonoids of the Artinsk from the relatively simple ones of the Pennsylvanian apparently took place in southwestern United States rather than in the region of the ancient Mediterranean as was formerly held, and the ammonoids described below confirm this belief. Only 3 species, representing 3 genera, are known from the Uralian, whereas 27 species, representing 8 genera, have been described previously from the Upper Pennsylvanian of the United States, 4 additional species and 1 genus have been mentioned by Scott and Plummer,[12] 10

[5]Keyte, I. A., Blanchard, W. G., and Baldwin, H. L., Gaptank-Wolfcamp problem of the Glass Mountains, Texas: Jour. Pal., Vol. 1, pp. 175-78, 1927.

[6]Schmidt, H., Die carbonischen Goniatiten Deutschlands: Jahrb. d. Preuss. Geol. Landes. 1924, Band 45, pp. 512-13, 1925.

[7]*Op. cit.*, p. 16.

[8]King, P. B., and King, R. E., The Pennsylvanian and Permian stratigraphy of the Glass Mountains: Univ. Texas Bull. 2801, p. 117, 1928.

[9]*Op. cit.*, pp. 64-65.

[10]*Op. cit.*, pp. 120-22.

[11]*Op. cit.*, p. 63.

[12]*Op. cit.*, p. 27.

species and 4 genera are added here, and Smith states that he has several undescribed species. Furthermore, the development of most of the stocks can now be traced directly from the Pennsylvanian into the Permian without going outside of the United States, and notwithstanding the post-Gaptank orogeny of western Texas a shallow sea must have existed in that general region continuously during the late Paleozoic.

Mr. King has supplied the following note as to the occurrence of the ammonoids described in this report.

THE OCCURRENCE OF THE AMMONOID FAUNA

The broader significance of the ammonoid fauna here described is well depicted by Mr. Miller, who shows that it represents one of the little known transitional stages between the cephalopods of Pennsylvanian and Permian time. It has been thought advisable to add a brief note on the field occurrence of the fauna, and to point out the bearing of Mr. Miller's findings on the local geology.

The fauna was discovered in 1927 by Robert E. King while engaged in mapping and collecting fossils in the Pennsylvanian of the Dugout Creek area west of the village of Marathon, Texas. We briefly mentioned its existence in University of Texas Bulletin 2801 (1928), although at that time insufficient study had been devoted to it to do more than indicate its general relationships. Because of the isolated location of the fossil-bearing layer the locality has remained nearly unvisited and uncollected since that time, though we have had the pleasure of visiting the spot with a few persons, including G. H. Girty, C. R. Longwell, and C. L. Baker. At the latest visit, in company with Mr. Baker, more material was gathered, both from the original locality and from a bed outcropping about one-half mile to the north, which Mr. Miller has shown to be of approximately the same age.

The ammonoids occur in strata which we have placed in the Gaptank formation, the highest member of the Pennsylvanian succession in the Marathon region. This correlation has been questioned by C. L. Baker, who proposes to speak of the strata by the noncommittal term, "Dugout beds," which he suggests may be much older than the Gaptank, possibly the northwestward marine facies of the Tesnus, Dimple, or Haymond formations which crop out farther southeast in the Marathon Basin. Structurally the evidence is equivocal, for the "Dugout beds" are nowhere found in normal contact with any of the older formations; to the north they pass beneath the Permian with great angular unconformity, while to the south they are overlain by Ordovician, Devonian, and early Carboniferous strata along the great Dugout Creek overthrust. The plane of the overthrust is nearly horizontal, and its trace is in places deeply indented along valleys which have cut entirely through the overthrust mass into the Pennsylvanian strata underneath. It is in one of the largest of these reentrant valleys that the ammonoids are found, a shallow basin about a mile in width, in which Pennsylvanian rocks outcrop as much as two miles to the south of the main front of the overthrust. With the exception of a few specimens, all the fossils collected came from a single great block of limestone lying

in a small gully three-quarters of a mile south of the present main front of the overthrust, one and three-quarters miles south of the Arnold Ranch, and four and one-half miles S. 15° E. of Lenox. The limestone block is about 7 feet square and is packed throughout with ammonoid shells. It appears to form part of an indistinct, steeply tilted limestone ledge striking east and west, which is much obscured by terrace gravels, but no ammonoids were found in either adjoining parts of this or nearby layers, suggesting that perhaps their occurrence is sporadic. That the limestone block is in place, or nearly in place, there can be little doubt, for the valley in which it lies drains only outcropping areas of the "Dugout beds" and pre-Carboniferous rocks. The terrace gravels above mentioned are all composed of these materials, but are chiefly fragments of Ordovician and Devonian chert and novaculite which only rerely reach the size of cobbles. That the layer is definitely a member of the "Dugout beds" is further confirmed by the two species of ammonoids collected at the second locality, *Marathonites hargisi* and *Schistoceras smithi*, which also occur in association with the other fossils at the original locality. At this second place the material was collected directly from limestone ledges which were in place, and which, when traced up the hillside were found to be truncated by the Dugout Creek overthrust and to be overlain by Devonian novaculites.

Mr. Miller has been able to show in his paper that the ammonoid fauna is of late Pennsylvanian age, and since the Gaptank formation at its type locality is known to be equivalent to the upper Strawn, the Canyon, and a part of the Cisco, there should be little hesitancy in placing this portion of the "Dugout beds" in the Gaptank formation. The field evidence, which is particularly plain at the second locality, shows beyond all reasonable doubt that these late Pennsylvanian strata have been involved in the movements of the Dugout Creek overthrust and were at one time entirely covered by a great overthrust mass of early Paleozoic rocks. This appears to support the writer's contention that the culminating phases of the Caballos disturbance are of post-Gaptank age.

On the other hand, it has been contended by Keyte, Blanchard, and Baldwin that a still younger ammonoid fauna, the *Uddenites* fauna of the Wolf Camp Hills, is also involved in the deformation. Though there is nothing in the present fauna, or in the field relations just described which would deny this contention, I believe that Mr. Miller makes it clear that the nature of the fauna in no way confirms the conclusion. It is true that an *Uddenites* very similar to *U. schucherti* does occur here, but it is in association with forms more primitive than any which have ever been found in the original *Uddenites* zone, thus indicating that the horizon is an older one.

PHILIP B. KING

DESCRIPTION OF GENERA AND SPECIES

GENUS ORTHOCERAS "BREYN"

There is considerable uncertainty at present as to the exact status of the genus *Orthoceras, s. str.* It is well known that the genus can not

be ascribed correctly to Breyn (Breynius), as has been done almost invariably in the past, and recent investigation has shown that the term *Orthoceras* is not in good standing as a nautiloid genus. This point will be discussed in detail by the writer in a future publication, but for the present it seems best to use the term in the accepted generic sense, i. e., referring to smooth (or nearly so), longiconic, orthoceraconic, orthochoanitic nautiloids.

ORTHOCERAS LONGISSIMICAMERATUM MILLER, N. SP.
Plate 38, figures 1, 2

Conch moderately small, orthoceraconic, and circular in cross-section. Nature of adapical part of shell and living chamber unknown. Rate of adoral expansion of phragmacone constant, and figured cotype expands from a diameter of 6½ mm. to 9 mm. in a length of 20 mm., which indicates an apical angle of a little more than 7 degrees. Shell thin, and fragments preserved on figured cotype are only about ¼ mm. thick. Surface of phragmacone, at least, marked by numerous fine ridges or raised lines, which are transverse to long axis of conch. The size and spacing of these ridges vary considerably, but in general six or seven of them occur in a length of 1 mm.

Septa simple saucer-shaped disks which are moderately convex apicad; amount of their curvature equal to approximately one-third their diameter. Camerae long, and their length, which gradually increases orad, is equal to about two-thirds their diameter. Sutures simple and straight and directly transverse to long axis of phragmacone.

Siphuncle central in position, circular in cross-section, and small; its diameter is equal to only about one-seventh that of phragmacone. Septal necks straight and short; only about one-tenth as long as camerae. Connecting rings straight, and segments of siphuncle are cylindrical in shape and apparently free from internal deposits.

Remarks. This description is based on 7 fragmentary specimens, the most nearly complete of which represents only 3½ camerae. However, they are moderately well preserved, and therefore most of the specific characters can be ascertained.

The long camerae of this form serve to distinguish it from most other similar Pennsylvanian species. However, it is resembled in this respect by *Orthoceras wapanuckense* Girty of the Caney shale, but that form is much less rapidly expanded orad and apparently the surface of its shell is smooth. The Carboniferous bactriticones also have long

camerae, but the marginal position of the siphuncle serves to distinguish them.

Occurrence. Upper part of Gaptank formation, 4.5 miles S. 15° E. of Lenox, Marathon Basin, Brewster County, Texas.

Cotypes. Peabody Museum of Natural History, Yale University, 12928.

BACTRITES POSTREMUS MILLER, N. SP.
Plate 38, figure 11

Conch long, straight, circular in cross-section (or very slightly compressed laterally), and slightly expanded orad; rate of adoral expansion of cotypes indicates an apical angle of only about 4 degrees. Adapical part of shell and living chamber unknown, but phragmacone attains a diameter of at least 17 mm. in large specimens. Shell thin and very finely striate; fragments preserved on cotypes are about ¼ mm. thick and are marked by very fine transverse striae, about 15 of which occur in a distance of 1 mm. As far as can be ascertained from the available material the striae are almost straight (very slightly sinuous) and are directly transverse to the long axis of the conch.

Septa moderately convex apicad, and amount of their curvature is equal to approximately one-third their diameter. Camerae long and their length, which gradually increases orad, is equal to about two-thirds their diameter. Sutures are simple circles with the exception of a long narrow tongue-shaped ventral lobe, which is about two-sevenths as long as the camerae and about one-fourth as wide as long. At its adapical end this lobe swells out into a knob-like expansion, which is supposed by J. P. Smith[13] to "represent a periodic repetition of the siphonal caecum." A narrow cylindrical connecting ring appears to extend from this knob-like expansion apicad into the funnel of the adjacent septum.

Remarks. With the probable exception of a single fragmentary specimen described by Thomas[14] from Peru, only three other authentic species of *Bactrites* are known from rocks younger than the Devonian, and all three are confined to the Moorefield and Caney shales, which are much older than the Gaptank. *Bactrites carbonarius* Smith[15] of the

[13]Smith, J. P., The Carboniferous ammonoids of America: U. S. Geol. Survey, Mon. 42, p. 31, 1903.

[14]Thomas, H. Dighton, An Upper Carboniferous fauna from the Amotape Mountains, north-western Peru: Geol. Mag., Vol. 65, p. 290, pl. 10, figs. 3, 3a, 1928.

[15]Thomas (*op. cit.*), apparently following Girty's suggestion (U. S. Geol. Survey Bull. 377, p. 52, 1909), refers this species to *Orthoceras*, but its affinities appear to the writer to be with *Bactrites*.

Moorefield[16] shale of Arkansas is very similar to the above described species, but the transverse striae of the former are sinuous, whereas those of the latter are essentially straight and the ventral lobes of the sutures of the two forms are not precisely similar. *Bactrites quadrilineatus* Girty of the Caney shale of Oklahoma is a smaller form with very distinctive surface sculpture; and *Bactrites smithianus* Girty of the same horizon and locality and of the Moorefield shale of Arkansas is marked by sinuous striae and "numerous little round spots" and its camerae are relatively longer.

The general nature of the septa and the sutures of the above described form is rather similar to that of *Spirula*, and *Bactrites* seems to represent the radicle out of which the Belemnoidea evolved. Most of the specimens on which the above description is based are covered with a thin layer of dark brown calcareous material, and therefore it was thought at first that this form might represent the beginnings of the Belemnoidea. However, the hypothesis was abandoned and the brown layer was attributed to secondary deposition during preservation, when it was noted that the layer is not of uniform thickness and even in thin-sections fails to reveal any indication of radiating structure, and that in some cases, at least, a similar brown layer invests the inside as well as the outside of the shell and is present on other types of ammonoids.

Occurrence. Abundant in upper part of Gaptank formation, 4.5 miles S. 15° E. of Lenox, Marathon Basin, Brewster County, Texas.

Cotypes. Peabody Museum of Natural History, Yale University, 12929.

Genus DARAELITES Gemmellaro

DARAELITES TEXANUS Böse

Plate 38, figures 27-29

Daraelites texanus Böse, *1919*, Univ. Texas Bull. 1762, pp. 52-54, pl. 1, figs. 1-8, 1917; Smith, *1929*, Am. Jour. Sci., 5th series, Vol. 17, pp. 66-68, fig. B, 17-26.

This species was described in detail by Böse from specimens collected in the Wolfcamp formation immediately northwest of Wolf Camp, Texas, and the original description has since been supplemented by J. P. Smith, who studied the types and also additional specimens from outcrops of the same formation 5 miles northeast of Wolf Camp. Therefore,

[16]In the original description of this species, J. P. Smith (U. S. Geol. Survey Mon. 42, p. 32, 1903) states that the types came from the "so-called 'Fayetteville shale' of the Arkansas geological survey," but G. H. Girty (U. S. Geol. Survey Bull. 439, p. 96, 1911) states that they came from the Moorefield shale.

little remains to be added to a description of the species, and it will suffice to state that the writer has 15 well preserved specimens and that they agree in almost every detail with the existing description of the species.

Smith states that "*D. texanus* has only the first lateral lobe slightly serrated, all the others are entire, contrary to Böse's statement, that the external lobe is slightly serrated on the side, and that the second lateral is also serrated." This statement is applicable to most of the specimens studied by the writer, but in the case of large specimens, some of which attain a diameter of 14 mm. and are septate throughout, there is a suggestion of serration on the apical part of the lateral subdivisions of the external lobe and the second lateral lobe. It is therefore quite probable that larger and more nearly complete specimens would show the sutures to be as stated by Böse.

This is the third species of *Daraelites*, which is so widespread in the Permian, to be recognized in the Pennsylvanian of southwestern United States. Girty[17] has described one from the Wewoka formation of Oklahoma and Scott and Plummer[18] have mentioned a second from the Cisco of north-central Texas. The fact that the Gaptank specimens are exceedingly similar to those occurring in the Wolfcamp seems to indicate that there is no great difference in the age of the two formations.

Occurrence. Upper part of Gaptank formation, 4.5 miles S. 15° E. of Lenox, Marathon Basin, Brewster County, Texas. Originally described from Wolfcamp formation (zone of *Uddenites*), immediately northwest of Wolf Camp, Glass Mountains, Brewster County, Texas, and since recognized from same formation 5 miles northeast of Wolf Camp.

Collection. Peabody Museum of Natural History, Yale University, 12930 (Gaptank specimens).

Genus PRONORITES Mojsisovics

PRONORITES PSEUDOTIMORENSIS Miller, n. sp.

Plate 38, figures 18-26

Mature specimens are discoidal, as whorls are high, increase in width relatively gradually, have flat, nearly parallel lateral sides, and are deeply involute. Ventro-lateral part of conch is evenly rounded, and ventral side is nearly flat but is slightly curved. Youngest volutions are only

[17]Girty, G. H., Fauna of the Wewoka formation of Oklahoma: U. S. Geol. Survey Bull. 544, pp. 247-248, pl. 34, figs. 5-5c, 1915.

[18]Scott, G., and Plummer, F. B., Geol. Soc. Am., Preliminary list of titles and abstracts of papers to be offered at the forty-second annual meeting, Washington, D. C., p. 27, 1929.

slightly impressed dorsally and are distinctly wider than high, but when whorls have attained a height of 4 mm. their width and height are approximately equal and they are moderately impressed. In outer volution whorls expand fairly rapidly in a dorso-ventral direction, but only very gradually laterally, and depth of impressed zone increases progressively. Whorls 7½ mm. high are 5½ mm. wide and are impressed to a depth of 2 mm.; those 21 mm. high are 13 mm. wide and are impressed to a depth of 6½ mm. In mature specimens height of whorl is greater than half diameter of specimen, but in younger stages of growth it is less than half.

Umbilicus small and becomes relatively smaller with increasing age, and only umbilical walls of older volutions are exposed. Specimens with a diameter of 12 mm. have an umbilicus about 4½ mm. wide, but width of umbilicus increases only slightly beyond this point, and that of specimens about 45 mm. in diameter measures only about 6 mm. Umbilical shoulders abrupt; umbilical walls steep.

EXPLANATION OF PLATE 38

All specimens figured are from the upper part of the Gaptank formation, 4.5 miles S. 15° E. of Lenox, Glass Mountains, Brewster County, Texas.

FIGS. 1, 2.—*Orthoceras longissimicameratum* Miller, n. sp. 1, Lateral view of a cotype, × 1; 2, diagrammatic longitudinal section based on another cotype showing nature of siphuncle, × 1.

3-10.—*Prouddenites primus* Miller, n. g., n. sp. 3-5, Lateral and ventral views of a cotype, × 1; 6, diagrammatic representation of a suture of same specimen as the preceding at a diameter of 33 mm. showing the irregular bifurcation of the subdivisions of the first lateral lobe on the right side of the specimen (reader's left), × 2; 7, diagrammatic representation of a suture of another cotype at a diameter of 12 mm., × 2; 8, diagrammatic representation of a suture of a third cotype at a diameter of 8 mm., × 4; 9, 10, diagrammatic representations of sutures of a fourth cotype at diameters of 5 mm. and 3 mm., respectively, × 4.

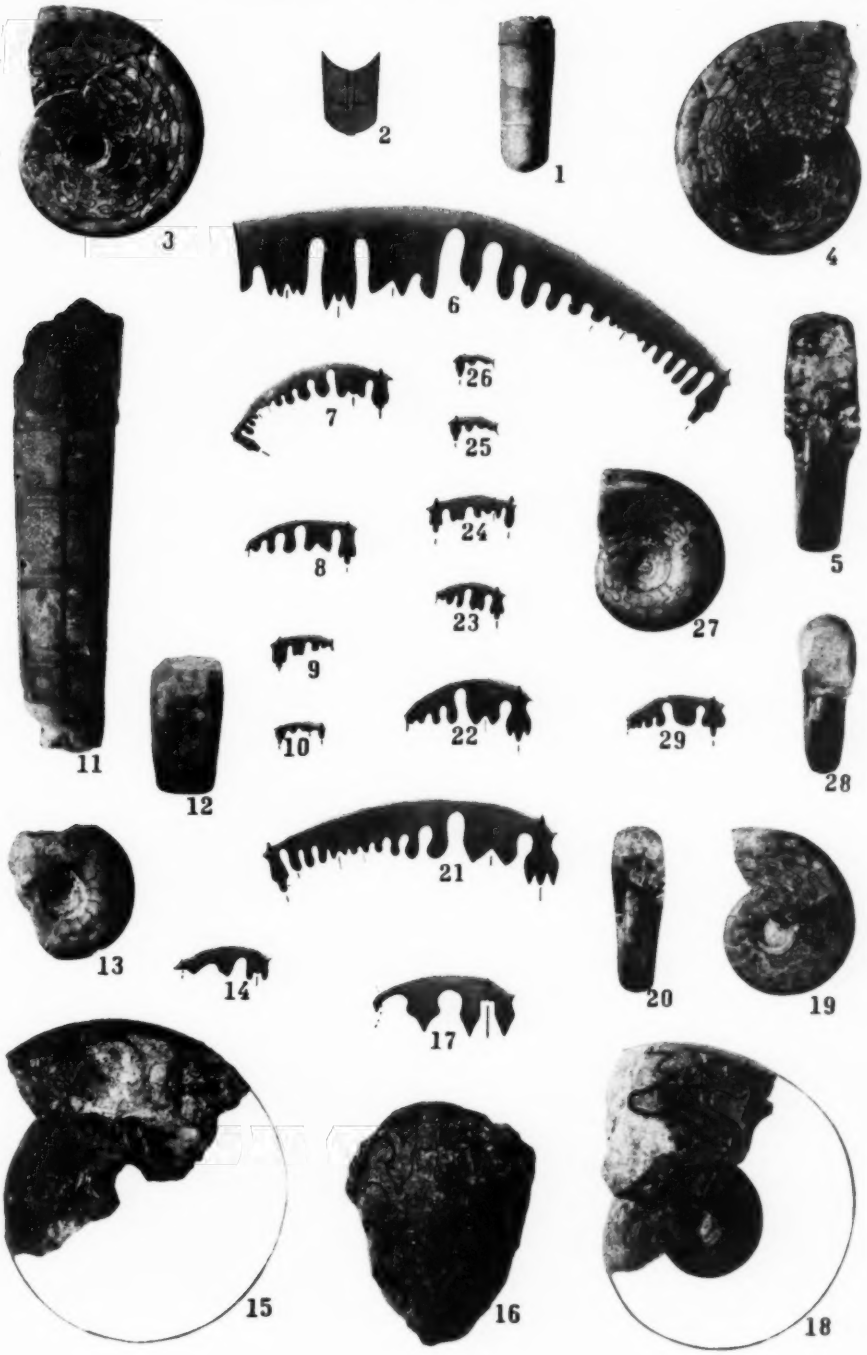
11.—*Bactrites postremus* Miller, n. sp. Ventral view of a cotype showing general nature of sutures, × 1.

12-14.—*Paralegoceras rectilaterale* Miller, n. sp. Ventral and lateral views and diagrammatic representation of a suture of a cotype, × 2.

15-17.—*Gastrioceras gaptankense* Miller, n. sp. Lateral and ventral views and diagrammatic representation of a suture of holotype, × 1.

18-26.—*Pronorites pseudotimorensis* Miller, n. sp. 18, Lateral view of one of the largest of the cotypes, × 1; 19, 20, lateral and ventral views of all but the last volution of same specimen as the preceding, × 1; 21-23, diagrammatic representations of sutures of same specimen as the preceding at diameters of 20 mm., 15 mm., and 10 mm., respectively, × 2; 24, diagrammatic representation of a suture of another cotype at a diameter of 3½ mm., × 4; 25,26, diagrammatic representations of sutures of a third cotype at diameters of about 2¾ mm. and 2 mm., respectively, × 4.

27-29.—*Daraelites texanus* Böse. Lateral and ventral views and diagrammatic representation of a suture of a larger specimen, × 2.



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Surface of internal mold smooth with the exception of a small longitudinal groove along the venter. This groove is very distinct on the internal mold, but apparently is not discernible from the outside of the shell.

At maturity the external suture outside of the umbilical shoulders consists of a trifid lobe and on each side of it six saddles and six lobes; the umbilical shoulder varies slightly in position with respect to the lobes and saddles, but in general it is just beyond the sixth lobe. There are two saddles and two lobes on the umbilical wall and a saddle on the umbilical seam, but in one of the large specimens studied by the writer there is a very small subangular lobe in the saddle between the two lobes, and the inner lobe is adjacent to the umbilical seam. The ventral lobe is short and broad and is strongly contracted near its base. All three of its subdivisions, as well as the intermediate secondary saddles, are pointed; on the outer volutions the lateral subdivisions are longer than the central one, but on the preceding volutions the reverse is the case. The external saddle is club-shaped and undivided. The first lateral lobe is on the curved ventro-lateral part of the conch. It is short, very broad, and symmetrically bifid; the secondary saddle is narrowly rounded and both of the subdivisions are pointed, but on the adoral sutures of three large fragmentary specimens the ventral subdivision is irregularly bifid; in one specimen it is bifid only on the right side of the conch as in a large specimen of *Pronorites timorensis* figured by Haniel,[19] in a second it is bifid only on the left side, whereas in the third it is bifid on both sides as in *Parapronorites*. The first lateral saddle is similar to the external saddle but is somewhat broader, less strongly contracted apicad, and exceptionally long. The broad first lateral lobe and the long first lateral saddle are the outstanding features of the suture. The second lateral lobe is asymmetrical, being distinctly curved toward the umbilicus, and is undivided. The second lateral saddle is similar to the first, but is only a little more than half as long. The auxiliary saddles are all club-shaped and undivided, and the lobes are similar but are more narrowly rounded. They decrease in size progressively toward the umbilicus, but the first auxiliary lobe projects slightly farther apicad than does the second lateral lobe. The lobes and saddles on the umbilical wall are similar to the last of the auxiliaries. The saddle on the umbilical seam is distinctly broader than the adjacent lobes and saddles, and the lobe that precedes it on the umbilical wall shows a tendency toward angularity.

[19]Haniel, C. A., Die Cephalopoden der Dyas von Timor: Pal. von Timor, III. Lieferung, p. 27, pl. 46, fig. 3, 1915.

The internal suture at maturity consists of a long dorsal lobe and on each side of it four saddles and four lobes. The dorsal lobe is long, narrow, rounded, and undivided; it is contracted both adapically and aperturally. Its contracted adapical part is in contact laterally with the apertural part of the dorsal lobe of the preceding suture. The rest of the lobes and saddles, which become smaller progressively toward the umbilical seam, are long, narrow, rounded, and undivided, and all are more or less club-shaped. The lobe adjacent to the dorsal shows a tendency toward angularity and is distinctly asymmetrical, being curved toward the umbilicus.

The development of the sutures in this species is essentially the same as in *Pronorites uralensis* Karpinsky.[20] The first whorls are only slightly impressed dorsally, and the exposed lateral part of the first sutures is essentially straight. Specimens with a diameter of about 2 mm. show a long narrow ventral lobe which is attenuated adapically, and on each side of it two saddles and two lobes and a third saddle on the umbilical shoulder; the second lobe and the third saddle are subangular, but the others are rounded. At a diameter of about 2¾ mm. the first auxiliary lobe appears, and the ventral lobe becomes more attenuated adapically. The number of lobes and saddles is not increased again until after the specimen has attained a diameter of more than 3½ mm., but the ventral lobe becomes distinctly trifid, the lateral subdivisions being very short, the first lateral lobe becomes bifid and the second asymmetrical, being curved toward the umbilicus. At this stage the internal suture consists of a long narrow spatulate ventral lobe, which is not in contact with that of the preceding suture; on each side of it is a short rounded saddle and lobe, and there is a rounded saddle on the umbilical seam. As the conch increases in size additional auxiliary lobes and saddles appear at the umbilical shoulder, the first lateral saddle becomes relatively longer, and the subdivisions of the ventral lobe become equal in size; eventually the lateral subdivisions become considerably longer than the central; otherwise the external sutures undergo comparatively little further development.

Remarks. This species is similar to *Pronorites arkansasensis* Smith from the Carboniferous of Arkansas, *Pronorites uralensis* Karpinsky from the Upper Coal Measures of the southern Urals, and *Pronorites timorensis*[21] Haniel from the lowest Artinskian of Timor. It is readily distin-

[20]Karpinsky, A., Über die Ammoneen der Artinsk-Stufe und einige mit denselben verwandte carbonische Formen: Mémoires de l'Académie Impériale des Sciences de St. Pétersbourg, VIIe série, tome 37, no. 2, pp. 8-11, pl. 1, figs. 4a-n, 1889.

[21]This form was described by Haniel as a variety of *Pronorites uralensis*, but it has since been shown to be specifically distinct by J. P. Smith (Permian ammonoids of Timor: Jaarboek van het Mijnwezen in Nederlandsch-Indië, 1926, Verhandelingen, eerste Gedeelte, pp. 13-14, 1927).

guished from the first two by the external sutures; its first lateral saddle is nearly twice as long as its second, and its first auxiliary lobe projects slightly farther apicad than the second lateral lobe. Externally, it appears to be essentially identical with the last of the above mentioned species, but it can be distinguished by the internal sutures; whorls of the Timor species about 7½ mm. high show five lobes on each side of the dorsal lobe, but those of the writer's specimens that are as much as 11 mm. high show only four.

Occurrence. Upper part of Gaptank formation 4.5 miles S. 15° E. of Lenox, Marathon Basin, Brewster County, Texas.

Cotypes. Peabody Museum of Natural History, Yale University, 12931.

GENUS PROUDDENITES MILLER, N. G.

The collection studied by the writer contains numerous representatives of a form that is intermediate between *Pronorites* and *Uddenites*, but is generically distinct from both. The name *Prouddenites* is here proposed for this intermediate type, and *Prouddenites primus*, the only known species, is the genotype.

Superficially this form appears to be strikingly similar to *Pronorites*, with which it is found in association, but it possesses the peculiar "adventitious" (or "first lateral") lobe that is characteristic of all the medlicottoid genera. This lobe is not very prominent, but it is sufficient to show that the genus is a true medlicottoid. It represents the most primitive possible stage of that group, and its development is quite in keeping with the horizon it marks; it is the only representative known to occur below the Permian, and it occurs in the highest Pennsylvanian just below the zone in which *Uddenites*, its direct descendant, is found. The discovery of it in Texas confirms the idea already extant that the medlicottoids developed out of *Pronorites* in the late Paleozoic sea there and spread thence all over the world during the Permian.

The development of the sutures in this genus is essentially the same as in *Uddenites*, but it does not progress quite as far. The ontogeny of the latter has been studied recently by J. P. Smith.[22] Both genera go through a *Prolecanites* and a *Paraprolecanites* stage during their larval development, and a *Pronorites* stage during their adolescence. They then both develop, by the modification of the dorsal subdivision of the bifid first lateral lobe, a peculiar lobe that is termed an adventitious

[22]Smith, J. P., The transitional Permian ammonoid fauna of Texas: Am. Jour. Sci., 5th series, Vol. 17, pp. 72-75, fig. A, 1-13, 1929.

lobe by Smith,[23] a principal adventitious lobe by Noestling,[24] and a first lateral lobe by Diener.[25] The ventral subdivision of the first lateral lobe subdivides again, and the two secondary subdivisions become subequal in size; in some of the large specimens being studied these subequal points are irregularly bifid. The development of *Prouddenites* stops at this stage, but in *Uddenites* the primary external rounded saddle becomes flat and the ventral part of the first lateral lobe subdivides twice and becomes greatly reduced in size. Further extensions of this same line of development are seen in *Propinacoceras*, *Artinskia*, and *Medlicottia*. It should also be mentioned that *Uddenites* is characterized by the presence of a wide deep longitudinal furrow along the venter, whereas in the writer's specimens there is only a small groove on the internal mold, as in *Pronorites*.

The new genus can be characterized as follows: Form discoidal, as conch is greatly compressed laterally and rather deeply involute. Whorls have flat, nearly parallel lateral sides and flattened ventral side; ventro-lateral part of whorls is rather narrowly rounded. Surface of mature shells is smooth with the exception of a small longitudinal groove on the venter; this groove is very distinct on the internal mold but apparently is not discernible from the outside of the shell. Umbilicus small, becoming relatively smaller as the conch develops, and in mature shells its diameter is only about one-fifth that of the specimen. Umbilical shoulders abrupt; umbilical walls steep. On the mature part of the conch the external suture consists of a trifid ventral lobe and on each side of it seven saddles and six lobes; there is also a small lobe on the umbilical shoulder, three saddles and three lobes on the umbilical wall, and a small saddle on the umbilical seam. The ventral lobe is short, broad, slightly contracted aperturally, and tridentate; all three of the points, as well as secondary saddles, are angular. The external saddle is almost straight-sided, rounded, and undivided. The first lateral lobe is exceedingly broad and is unequally trifid; the central and ventral subdivisions are subequal but differ from the dorsal. They, and the saddle dividing them, which is located on the narrowly rounded ventro-lateral part of the conch, are obtusely pointed, but in some cases on large specimens they are irregularly bifid. The dorsal subdivision of the first lateral lobe, one

[23]*Op. cit.*

[24]Noetling, Fritz, Ueber *Medlicottia* Waag. und *Episageceras* n. g. aus den permischen und triadischen Schichten Indiens: N. Jahr. f. Min., Geol. u. Pal., Beil.-Bd. 19, pp. 334-376, pls. 17-20, 1904.

[25]Diener, Carl, Über Ammoniten mit Adventivloben: Denkschr. d. kaiserl. Akad. d. Wissen. in Wien, math.-naturwissen. Klasse, Band 93, p. 165, 1915.

of the most significant parts of the suture, is short, subangular, and asymmetrical. It is separated from the other two subdivisions by a short rounded somewhat asymmetrical secondary saddle. The first lateral saddle is similar to the external but is broader and longer. The second lateral lobe is club-shaped and is unequally bifid. The rest of the lobes and saddles, which become progressively smaller toward the umbilicus, are undivided and club-shaped; the saddles are rounded, but the lobes show a tendency toward angularity. The lobes and saddles on the umbilical wall are all small and more or less rounded. The internal suture at maturity consists of a long narrow spatulate bifid dorsal lobe that is contracted both adapically and aperturally, and on each side of it seven saddles and seven lobes, which are all long, narrow, and undivided; the saddles are rounded but the lobes show a tendency toward angularity. They become progressively shorter and relatively broader toward the umbilical seam.

PROUDDENITES PRIMUS MILLER, N. G., N. SP.
Plate 38, figures 3-10

Form discoidal, as conch is greatly compressed laterally and rather deeply involute. Whorls have flat, nearly parallel lateral sides and flattened ventral side; ventro-lateral part of whorls is narrowly rounded. Earliest volutions are only slightly impressed dorsally, approximately as wide as high, and rounded ventrally; but before whorls have attained a diameter of 1 mm. their height becomes greater than their width and they are slightly flattened ventrally. In the other volutions the conch expands fairly rapidly in a dorso-ventral direction but very slowly in a lateral, and it becomes progressively more deeply involute with age. Whorls 6 mm. high are 3½ mm. wide and are impressed to a depth of 1½ mm.; those 17 mm. high are 9 mm. wide and are impressed to a depth of 5½ mm.; and those 19 mm. high are about 10 mm. wide. In outer volutions height of whorl is approximately equal to half diameter of specimen.

Umbilicus small and becomes relatively smaller as the conch develops and the whorls become more deeply impressed. Specimens of a diameter of 11 mm. have an umbilicus 4 mm. wide, and a considerable portion of the internal whorls is exposed; specimens of a diameter of 33½ mm. have an umbilicus 6½ mm. wide and only the umbilical wall of the preceding volution is exposed. Umbilical shoulders very abrupt; umbilical walls steep.

Surface of internal mold smooth with the exception of a small longitudinal groove along the venter. This groove is very distinct on the internal mold but does not appear to be discernible from the outside of the shell. On the small inner whorls there is an indication of faint sigmoidal transverse lateral striae.

On the outer whorl of mature specimens the external suture consists of a trifid ventral lobe and on each side of it seven saddles and six lobes; there is also a small lobe on the umbilical shoulder, three saddles and three lobes on the umbilical wall, and a small saddle on the umbilical seam. The ventral lobe is moderately short and broad and is slightly contracted aperturally. All three of its subdivisions, as well as the intermediate secondary saddles, are pointed. On the outer volution the lateral subdivisions are longer than the central one, but on the preceding volution the reverse is the case. The external saddle is almost straight-sided, rounded, and undivided. The first lateral lobe is exceedingly broad and short and is unequally trifid; the central and ventral subdivisions are subequal but differ from the dorsal. With the saddle that divides them, located on the narrowly-rounded ventro-lateral part of the conch, they are obtusely pointed; but in some large specimens they are irregularly bifid. The dorsal subdivision of the first lateral lobe is short, subangular, and asymmetrical; it is separated from the other two subdivisions by a short rounded somewhat asymmetrical secondary saddle, but it is in contact (or nearly so) with the first lateral saddle of the preceding suture. The first lateral saddle is similar to the external but is broader and longer. The second lateral lobe is club-shaped and is unequally bifid, the dorsal subdivision being longer than the ventral; both subdivisions and the dividing secondary saddle are small and pointed. The rest of the lobes and saddles, which become progressively smaller toward the umbilicus, are undivided and more or less club-shaped; the saddles are rounded, but the lobes show a tendency toward angularity. The lobes and saddles on the umbilical wall are all small and more or less rounded.

The internal suture consists of a long narrow bifid dorsal lobe that is contracted both adapically and aperturally, and on each side of it are seven saddles and seven lobes, which are all long, narrow, and undivided; the saddles are rounded, but the lobes show a tendency toward angularity. The dorsal lobe is in contact for a considerable part of its length with the dorsal lobes of the preceding and the following sutures. The lobe adjacent to the dorsal is located on the narrowly rounded part of the conch and it is slightly asymmetrical, being curved toward the umbilical seam.

The development of the sutures is essentially the same as in *Uddenites*, but it does not progress quite as far. Specimens with a diameter of 3 mm. show externally a long undivided ventral lobe, the adapical part of which is considerably attenuated, and on each side of it are three small rounded saddles and two similar lobes; and there is a third lobe on the umbilical seam. At this stage the internal suture consists of a moderately long narrow U-shaped dorsal lobe, which appears to be separated from the lobe on the umbilical seam by only a single broad shallow saddle. At a diameter of 5 mm. the ventral lobe becomes distinctly trifid, the two lateral subdivisions, however, are not very prominent; the first lateral lobe is bifid, the second is club-shaped and the first auxiliary, which is a considerable distance from the umbilical shoulder, is rounded. All three saddles are rounded, and there is a fourth saddle on the umbilical shoulder. At a diameter of 8 mm. the ventral subdivision of the first lateral lobe gives rise to a small lobe on its dorsal side; as the conch increases in size this lobe moves dorsad gradually and eventually becomes approximately equal in size to its progenitor. The dorsal subdivision of the first lateral lobe remains narrow and undivided; it gradually moves dorsad and becomes asymmetrical. The saddle that separates it from the other subdivisions of the lobe deepens slightly and also becomes asymmetrical. The first lateral saddle remains longer than the external saddle, and at a diameter of about 25 mm. the second lateral lobe subdivides. Meanwhile additional lobes and saddles have been added at the umbilicus.

At a diameter of 12 mm. the internal suture consists of a long narrow bifid ventral lobe that is attenuated at both ends, and on each side of it are three club-shaped lobes and three similar saddles; there is a fourth saddle on the umbilical seam. At a diameter of 33 mm. there are seven lobes and seven saddles on each side of the ventral lobe, and all are longer and narrower than they were in the preceding stage.

Remarks. On the outer whorl of nine of the numerous large specimens being studied by the writer, the ventral and central subdivisions of the first lateral lobe are irregularly bifid. On the figured specimen both of these subdivisions are distinctly bifid on the right side of the conch but undivided on the left (with the exception of a very small nick in the dorsal side of the ventral subdivision in the outermost sutures of the specimen). In some of the specimens all four of these subdivisions (two on each side) are bifid, in others only three, and in some only one. The development of this secondary bifurcation is extremely irregular; in some of the specimens it appears first in the ventral subdivisions, in others in the dorsal; in some first on the left side of the conch, in others

on the right. This irregular bifurcation is comparable to that which occurs in large specimens of *Pronorites pseudotimorensis* and that which has been noted by Haniel[26] in *Pronorites timorensis*. In *Parapronorites* these secondary lobes are regularly bifid, and the fact that they are irregularly so in some large examples of *Pronorites* and *Prouddenites* is further proof of the close relationship of these three genera. Both *Parapronorites* and *Prouddenites* developed out of *Pronorites*.

It should also be pointed out that in the adolescent stage of *Uddenites schucherti*,[27] which corresponds very closely to the mature *Prouddenites primus*, the second lateral lobe is distinctly bifid as it is in *Prouddenites*, but in the mature sutures of *Uddenites* this lobe is undivided. This fact is further proof that *Uddenites* is a direct descendant of *Prouddenites*.

Occurrence. Abundant in upper part of Gaptank formation, 4.5 miles S. 15° E. of Lenox, i. e., 1¾ miles due south of Arnold Ranch, Marathon Basin, Texas.

Cotypes. Peabody Museum of Natural History, Yale University, 12932 and 12942.

Genus UDDENITES Böse

UDDENITES SCHUCHERTI Böse

Plate 39, figures 17-19

Uddenites schucherti Böse, *1919*, Univ. Texas Bull. 1762, pp. 60-63, pl. 1, figs. 9-23, 1917; Smith, *1929*, Am. Jour. Sci., 5th series, Vol. 17, pp. 72-75, fig. A, 1-13.
Uddenites minor Böse, *1919*, Univ. Texas Bull. 1762, pp. 63-66, pl. 1, figs. 24-40, 1917.

This species is represented in the collections by a single fragmentary specimen in the adolescent stage of development. The maximum diameter of that specimen is about 12 mm. and the maximum width about 2½ mm. Its sutures correspond to those figured by Smith of specimens of slightly smaller diameter, but a study of several well preserved representatives of this species from the zone of *Uddenites* at the base of the Wolfcamp formation has shown that the rate of development of the sutures varies slightly in different individuals.

It is possible that mature specimens of this form from the upper Gaptank may show differences of varietal or even specific value from those of the basal Wolfcamp, but the single Gaptank specimen available for study fits the existing descriptions of the Wolfcamp specimens so well that a detailed description of it is superfluous.

[26]Haniel, C. A., Die Cephalopoden der Dyas von Timor: Pal. von Timor, III. Lieferung, p. 27, pl. 46, fig. 3, 1915.

[27]Figured by Smith, J. P., *op. cit.*, fig. 4A.

Occurrence. Upper part of Gaptank formation, 4.5 miles S. 15° E. of Lenox, Marathon Basin, Brewster County, Texas (figured specimen). Originally described from Wolfcamp formation (zone of *Uddenites*), immediately northwest of Wolf Camp, Glass Mountains, Brewster County, Texas, and since recognized from same formation 5 miles northeast of Wolf Camp. Also, Scott and Plummer[28] have mentioned orally the occurrence of a form doubtfully referred to this species in the Cisco of north-central Texas.

Figured specimen. Peabody Museum of Natural History, Yale University, 12945.

Genus GASTRIOCERAS Hyatt

GASTRIOCERAS GAPTANKENSE miller, n. sp.

Plate 38, figures 15-17

Form subglobose, conch strongly depressed dorso-ventrally, whorls impressed to about one-third of their height by preceding volution, helmet-shaped in cross-section. Height of whorl equal to slightly less than half greatest width, which is attained just ventrad of umbilical shoulders. Umbilical shoulders abruptly rounded; width of umbilicus equal to about two-fifths diameter of conch. Internal mold smooth except for faint sinuous constrictions, which are common in the Glyphioceratidae. These form broad shallow "saddles" as they cross the venter and shallow "lobes" along the ventro-lateral sides of the whorls. There appear to be about three or four constrictions to a volution.

Each suture consists of a pair of pointed tongue-shaped ventral lobes divided by a slightly wider blunt ventral saddle, and on each side of them a longer moderately broad tongue-shaped saddle which is rather strongly constricted laterally, a very broad pointed tongue-shaped lateral lobe, an equally broad shallow rounded lateral saddle, and a short broad pointed lobe just inside the umbilical shoulder. Internal sutures not exposed on any of the types.

Remarks. The above description is based largely on a single fragmentary specimen representing only parts of two whorls of the phragmacone, but two other fragmentary specimens are available for comparison. The holotype seems to have attained a maximum diameter of about 40 mm. (estimated) and a maximum width of about 30 mm. (estimated).

[28]Scott, G., and Plummer, F. B., Forty-second annual meeting of the Geol. Soc. Am., December, 1929.

This species is evidently rather closely related to *Gastrioceras illinoisense* (Miller and Gurley) of the Upper Coal Measures of Illinois, *G. kansasense* (Miller and Gurley) of the Upper Coal Measures of Missouri, and *G. hyattianum* Girty of the Wewoka formation of Oklahoma. It seems to resemble the first of these more closely than any other described species, but that form is free from sinuous constrictions, appears to be considerably smaller, and the lateral lobes of its sutures are narrower and less acuminate.

Occurrence. Upper part of Gaptank formation, 4.5 miles S. 15° E of Lenox, i. e., 1¾ miles due south of Arnold Ranch, Marathon Basin, Texas.

Holotype (and fragmentary paratypes). Peabody Museum of Natural History, Yale University, 12933 (holotype and paratype) and 12944 (paratype).

Genus PARALEGOCERAS Hyatt

PARALEGOCERAS RECTILATERALE Miller, n. sp.

Plate 38, figures 12-14

Form discoidal, as whorls are greatly flattened laterally and ventrally, almost subangular ventro-laterally, deeply impressed dorsally, and U-shaped in cross-section. Lateral sides, which are only very slightly curved, are at approximately 90 degrees to flat ventral side. Conch is expanded orad rather gradually, and whorls are impressed to nearly one-half their height by preceding volution. Height of whorl equal to

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Explanation of Plate 39

All specimens figured are from the upper part of the Gaptank formation, 4.5 miles S. 15° E. of Lenox, Glass Mountains, Brewster County, Texas.

Figs. 1-5.—*Marathonites hargisi* Böse. 1,2, Lateral and ventral views of a large specimen showing living chamber, × 1; 3, 4, ventral and lateral views of phragmacone of another mature specimen, × 1; 5, diagrammatic representation of a suture based on same specimen as the preceding (external suture) and another specimen (internal suture), × 2.

6-9.—*Schistoceras reticulatum* Miller, n. sp. 6, 7, Lateral view and diagrammatic representation of a suture of holotype, × 1; 8, 9, ventral and lateral views of all but adoral half of last volution of holotype showing surface ornamentation characteristic of the earlier volutions, × 2.

10-13.—*Prothalassoceras kingorum* Miller, n. sp. 10, 11, Lateral and ventral views of a small specimen, × 2; 12, 13, diagrammatic representations of the suture of a second small specimen and of a large specimen, × 2.

14-16.—*Schistoceras smithi* Böse. Lateral and ventral views and diagrammatic representation of a suture of same specimen, × 1.

17-19.—*Uddenites schucherti* Böse. Lateral and ventral views and diagrammatic representation of a suture of a specimen in the adolescent stage of development, × 2.

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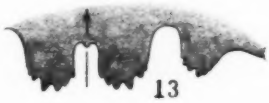
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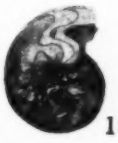
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about one-third diameter of specimen and about three-fifths maximum width, which is attained about mid-height of lateral sides of conch. Umbilical shoulders broadly rounded; diameter of umbilicus equal to about two-fifths that of specimen.

Surface of internal mold of outer whorl marked by two transverse constrictions, which are nearly straight along the lateral sides of the conch but curve rather strongly orad as they cross the venter. There is a conspicuous rounded depression in the constrictions near the center of the lateral sides of the conch. Each suture consists of a very broad short blunt straight-sided ventral lobe, and on each side of it a short broad rounded asymmetrically U-shaped external saddle, a slightly shorter and broader pointed first lateral lobe, the dorsal side of which is notched near the apex by a small broad shallow rounded secondary saddle which is on the narrowly rounded ventro-lateral part of the conch, a very broad short asymmetrical rounded first lateral saddle, a very broad short slightly asymmetrical angular second lateral lobe, a very shallow rounded second lateral saddle on the umbilical shoulder, and an equally shallow rounded lobe on the umbilical wall; there appears to be a broad shallow angular saddle on the umbilical seam. The ventral lobe is almost as broad as long; it is divided by a broad short median saddle, which is about one-third as long as the lobe and is centrally notched. The two lateral subdivisions of the ventral lobe are straight-sided, rounded, and undivided, and they are somewhat narrower than the median saddle.

Remarks. This species is based on two specimens. The cross-section of its whorls is very different from that of all other described species of this genus. It resembles *Paralegoceras iowense* (Meek and Worthen), the genotype, more closely than any other known form, but is smaller, much less strongly compressed laterally, and flattened rather than rounded ventrally.

Occurrence. Upper part of Gaptank formation, 4.5 miles S. 15° E. of Lenox, Glass Mountains, Brewster County, Texas.

Cotypes. Peabody Museum of Natural History, Yale University, 12934.

Genus SCHISTOCERAS Hyatt

SCHISTOCERAS RETICULATUM Miller, n. sp.

Plate 39, figures 6-9

Form subglobose, conch expanded orad rather rapidly, whorls depressed dorso-ventrally, rounded ventrally, only slightly flattened laterally, impressed dorsally, and helmet-shaped in cross-section. Height

of whorl equal to about three-sevenths diameter of specimen and about three-fifths maximum width, which is attained just ventrad of umbilical shoulders; the whorls are impressed dorsally to about one-third their height by preceding volution. Umbilicus rather broad and deep, its diameter equal to about two-sevenths diameter of specimen; umbilical shoulders rounded; and umbilical walls at almost 90 degrees to lateral sides of conch.

Surface sculpture varies with stage of growth. The inner whorls of the holotype are not visible, but up to a diameter of 15 mm. the entire surface of the shell is marked by numerous fine transverse undulating striae. These are convex apicad along the lateral sides of the conch, convex dorsad along the ventro-lateral sides, and convex apicad along the ventral side. The lateral sides also bear a row of rounded short transverse ribs or transversely elongated nodes, which are a little more than 1 mm. apart and are parallel to the transverse striae. They are very prominent on the umbilical shoulders, but become less so both ventrad and dorsad, and are confined to the lateral sides of the conch. There is no indication of longitudinal striae on this part of the specimen.

The lateral ribs become less prominent orad and are not discernible on the part of the specimen that is more than 15 mm. in diameter. The transverse striae, however, are present throughout the entire length of the holotype, and they appear to become more prominent on the umbilical shoulders and lateral sides of the conch as the ribs become less so. Small fragments of the shell preserved on the adoral part of the specimen show very clearly that at least that part of the conch was marked by both longitudinal and transverse striae. These are all of about equal prominence, and they give the shell a reticulate appearance. Transverse striae are visible on the dorsal side of the last volution, but since they are parallel to those on the ventral side of the preceding volution they may not be original there.

The external suture consists of a short broad ventral lobe, which is divided by a prominent median saddle, and on each side of it four saddles and four lobes; the fourth saddle is on the umbilical shoulder and the fourth lobe on the umbilical wall. The median saddle of the ventral lobe is long, slender, and blunt, and it is centrally notched; it is not much shorter than the ventral lobe. Its sides are slightly sigmoidal, and as it is contracted about mid-height, it is somewhat bottle-shaped. Each of the branches of the ventral lobe is of about the same size and shape as the median saddle, but it is pointed. On the last volution of the holotype the median saddle is distinctly narrower than the branches of the

ventral lobe, but on the preceding volution the reverse is true. The external saddle is similar to the median saddle of the ventral lobe but is considerably longer and broader and is undivided. The first lateral lobe is similar to the branches of the ventral lobe but is distinctly shorter. The first lateral saddle is similar to the external saddle but is shorter. The second lateral lobe is shorter than the first and is not contracted near mid-height. The second lateral saddle is only about half as long as the first, it is almost straight-sided and is very blunt. The first auxiliary lobe is located just ventrad of the umbilical shoulder. It is very short and is asymmetrically funnel-shaped; its ventral side is convex, but its dorsal is concave. The first auxiliary saddle is located on the umbilical shoulder. It is very broad and shallow; its length is equal to only about two-fifths its width. There is a short pointed symmetrically funnel-shaped lobe on the umbilical wall. It is not central in position but is distinctly nearer the dorsal than the ventral side of the whorl.

The internal suture consists of a long narrow dorsal lobe and on each side of it three saddles and two lobes; the third saddle is on the umbilical seam. The dorsal lobe is long, slender, straight-sided, and acuminate. The adjacent saddle is slightly broader and shorter, and it is asymmetrically U-shaped. The first lateral lobe is still shorter and broader and is hastate. The next saddle is only about half as high as the preceding one and, like it, is asymmetrically U-shaped, but the curvature that causes the asymmetry is reversed. The second lateral lobe is just inside the umbilical seam. It is short, pointed, and asymmetrically funnel-shaped; its dorsal side is convex, its ventral concave. There is a third saddle on the umbilical seam. It is rounded and is short and broad; its width and its height are about equal. It is followed by the lobe on the umbilical wall described above.

Remarks. This species is based on a single moderately well preserved specimen and a fragment of a second. It is more strongly depressed dorso-ventrally than any other described species of this genus, but it is similar to *Schistoceras hildrethi* (Morton) of the "Upper Coal Measures ('Lower Barren'), near Cambridge, Guernsey County, Ohio," and *S. diversecostatum* Böse of the Wolfcamp formation of the Glass Mountains, Texas. Its external sutures and surface ornamentation appear to be considerably different from those of the former, and its internal sutures are markedly different from those of the latter, in which the first lateral lobes are said to be much longer than the dorsal lobe. The surface ornamentation is similar to that of three fragmentary specimens that are being referred with question to *S. smithi*, and it is possible

that the types of this species may eventually prove to be merely immature representatives of the species. However, since both of the types retain part of the living chamber and are of about the same size, it seems logical to regard them as mature individuals, and they are very much smaller than mature representatives of *S. smithi*.

Occurrence. Upper part of Gaptank formation, 4.5 miles S. 15° E. of Lenox, Glass Mountains, Brewster County, Texas.

Holotype (and fragmentary paratype). Peabody Museum of Natural History, Yale University, 12935.

SCHISTOCERAS SMITHI BÖSE

Plate 39, figures 14-16.

Schistoceras Smithi BÖSE, *1919*, Univ. Texas Bull. 1762, pp. 93-95, pl. 3, figs. 9-16, 1917.

This species is represented in the collections studied by the writer by a single well preserved specimen and two fragmentary ones, five additional fragments being referred to it with question. The writer's specimens agree in almost every detail with those described by Böse. It should, however, be pointed out that the details of the sutures in the same and different specimens show considerable variation, particularly in regard to the relative widths of the different lobes and saddles. This fact is apparent from a study of the sutures of the two specimens figured by Böse, and it becomes more obvious when additional specimens are taken into consideration. In the writer's nearly complete specimen the sides of the median saddle in the ventral lobe are slightly more sigmoidal than in either of the types, and the saddle is somewhat more nearly bottle-shaped as it is distinctly contracted near mid-height. Otherwise the sutures are similar to those figured by Böse.

Three fragmentary specimens referred with question to this species are similar in ornamentation to *Schistoceras reticulatum*, but two of them represent specimens as large as mature representatives of the species under consideration, and the third, which appears to represent part of one of the inner whorls, bears short umbilical ribs or transversely elongate nodes that are much more prominent than those on the inner whorls of *S. reticulatum*. It is possible that these fragmentary specimens represent a distinct species, but until the surface ornamentation of *S. smithi* can be shown to be different, they had best be referred to that species.

It should also be mentioned that Böse described this form as *Schistoceras Smithi* and referred to it as such elsewhere in the same publication (pp. 93, 95, and 98), but in the explanation of plates he listed it as *Schistoceras J. P. Smithi*.

Occurrence. Upper part of Gaptank formation, 4.5 miles S. 15° E. of Lenox, Marathon Basin, Brewster County, Texas, and ½ mile north of the preceding locality, i. e., at the east end of the Novaculite Hills just below the overthrust. Originally described from same formation, about 2 miles south of Gap Tank, Glass Mountains, Texas.

Collection. Peabody Museum of Natural History, Yale University, 12936 (specimens from 4.5 miles of Lenox), 12940 (specimens from Novaculite Hills).

Genus PROTHALASSOCERAS Böse

PROTHALASSOCERAS KINGORUM[1] Miller, n. sp.

Plate 39, figures 10-13

Form subdiscoidal, conch deeply involute, rather narrowly rounded ventrally, and flattened laterally. Young stages, however, are subglobose, but lateral sides become progressively flatter with increasing age, and mature shells are subdiscoidal. In a specimen with a diameter of 10 mm., maximum width of whorl, which is attained just ventrad of umbilical shoulder, measures 6.5 mm. and is slightly greater than height of whorl, 6 mm. In largest specimen available for study, maximum width of whorl is about 8 mm. (estimated), whereas height of whorl is about 12 mm. However, this specimen is rather fragmentary and may have been flattened laterally during preservation. Umbilicus very narrow, umbilical walls steep, and umbilical shoulders rounded. There is no indication of any surface ornamentation on any of the specimens studied.

In large specimens the external suture consists of a pair of broad ventral lobes divided by a short broad U-shaped median saddle, which is notched at the center. The adapical part of the ventral lobes is serrated; there are six serrations in each lobe, and they increase in size progressively toward the center. The external saddle is moderately short and broad, and it is straight-sided, rounded, and undivided. The first lateral lobe is short and broad; its apical part is divided into five serrations, but it is asymmetrical and there are three serrations on the ventral side of its apex and one on the dorsal. The lateral saddle is very broad and shallow; it is evenly rounded and undivided. There is a short broad rounded lobe just inside the umbilical shoulder on the umbilical wall. The internal sutures consist of a long narrow pointed dorsal lobe and on each side of it a broader U-shaped saddle, a shorter narrow spatulate lobe, and a broad shallow rounded saddle which extends to the rounded

[1]Named in honor of P. B. and R. E. King, who collected most of the material on which this report is based.

lobe on the umbilical wall. None of the internal lobes or saddles is serrated.

The lobes of the external sutures appear to have become serrated very early in the development of the shell. The smallest specimen on which the writer has been able to study sutures successfully is only 3 mm. in diameter, but the general plan of its sutures is almost identical with that of larger specimens, and there is even a suggestion of serration on the apical parts of the lobes. As the shell increases in size the serrations become progressively more prominent and more numerous, and the maximum number of serrations is not present on the lobes of specimens 12 mm. in diameter.

Remarks. The above description is based on 14 moderately well preserved specimens, but only two of them attain a diameter of more than 12 mm., and all but one rather poorly preserved specimen are septate throughout. Therefore little is known as to the nature of the youngest sutures and the living chamber, but the latter appears to be at least 1 volution in extent.

Prothalassoceras welleri Böse of the Hess formation of the Glass Mountains appears to be a larger form, and the lobes of its external sutures appear to bear more numerous serrations, but these differences may be due to the larger size of the only known representative of that species. *P. keytei* Smith of the Wolfcamp formation (zone of *Uddenites*) of the Glass Mountains also seems to be known from only one specimen, which apparently is immature, and therefore adequate comparisons are not possible. The lobes of its external sutures seem to be serrated differently from those of the species under consideration, but this may be due to differences in preservation. It is possible that *P. kingorum*, *P. keytei*, and *P. welleri* may all prove to be conspecific when they are fully known. Scott and Plummer[29] have mentioned the occurrence of a species of *Prothalassoceras* in the Pennsylvanian of north-central Texas, but neither description nor illustration of that form has been published as yet.

P. gemmellaroi (Karpinsky) of the Artinsk of the southern Urals has a distinctly different suture. The figured type[30] of that species is quite small and may be an immature representative of *Thalassoceras* Gemmellaro of the Sosio beds of Sicily; but until specimens with sutures

[29]Scott, G., and Plummer, F. B., *Op. cit.*

[30]Karpinsky, A., Über die Ammoneen der Artinsk-Stufe und einige mit denselben verwandte carbonische Formen: Mém. de l'Acad. Impériale des Sciences de St. Pétersbourg, VIIe sér., tome 37, no. 2, pl. 4, figs. 3 a-d, 1889.

resembling those of the Sicilian forms in degree of complexity have been found, the species had best be referred to *Prothalassoceras*.

Occurrence. Upper part of Gaptank formation, 4.5 miles S. 15° E. of Lenox, i. e., 1¾ miles due south of Arnold Ranch, Marathon Basin, Texas.

Cotypes. Peabody Museum of Natural History, Yale University, 12937 and 12943.

Genus MARATHONITES Böse

MARATHONITES HARGISI Böse

Plate 39, figures 1-5

Marathonites ? Hargisi Böse, *1919*, Univ. Texas Bull. 1762, pp. 144-146, pl. 7, figs. 33-39, 1917.

Form subglobose as conch is expanded orad very gradually and whorls are depressed dorso-ventrally, crescent-shaped in cross-section, broadly rounded ventrally, only slightly flattened laterally, and deeply impressed dorsally. Height of whorl equal to slightly less than half diameter of specimen and about three-fourths maximum width of whorl, which is attained just ventrad of umbilical shoulders; whorls are impressed to slightly more than half their height by preceding volution. Umbilicus moderately small, its diameter equal to only about one-third diameter of specimen, and only the umbilical shoulders of all but the last volution are visible. Umbilical shoulders are sharp, and umbilical wall makes an angle of almost 90 degrees with lateral sides of conch. Length of living chamber unknown, but all of the last whorl of the writer's largest specimen, which attains a diameter of 32 mm. and a maximum width of 20.5 mm. but is incomplete aperturally, is non-septate and is therefore assumed to represent living chamber.

Whorls are marked by three slightly sinuous constrictions, which in large specimens are about 1 mm. wide. They curve slightly apicad as they cross the venter and slightly orad along the ventro-lateral sides of the conch. Surface of shell also marked by numerous fine transverse striae, which are approximately parallel to the constrictions. On outer whorl of large specimens these striae are approximately ½ mm. apart. There is no indication of the sinuous constrictions on small specimen, i. e., those of a diameter of less than 5 mm., but the transverse striae are very distinct on them.

Septa numerous and close together, but not in contact. The external suture consists of a broad ventral lobe, which is divided by a prominent median saddle, and on each side of it five saddles and five lobes.

The fifth saddle is on the umbilical shoulder, the fifth lobe on the umbilical wall, and it is followed by a saddle on the umbilical seam. The median saddle of the ventral lobe is club-shaped and is centrally notched. Its length is equal to about three-fifths that of the lobe. The two branches of the ventral lobe are of about the same size and shape as the median saddle, and they also are bifid, but asymmetrically so, as the ventral point is distinctly longer than the dorsal. All of the other saddles are rounded and undivided. They, together with the lobes, decrease in size progressively toward the umbilicus. The external saddle is club-shaped, as it is rather strongly contracted near its adapical end; the first lateral saddle is only slightly so. The second lateral and the first auxiliary saddles are almost straight-sided and therefore U-shaped; the second auxiliary, which lies on the umbilical shoulder, and the saddle that lies on the umbilical seam are short, broad, and depressed U-shaped. The first lateral lobe is narrower than the adjacent saddles, club-shaped, and asymmetrically bifid; the dorsal point is distinctly longer than the ventral. The second lateral lobe is trifid, and the central point is longer than the lateral ones. The first auxiliary lobe is almost straight-sided and is more or less asymmetrically bifid; the second is funnel-shaped, undivided, and subangular; and the third, which lies on the umbilical wall, is similar to the second but is somewhat smaller. The internal suture consists of a trident dorsal lobe, all the subdivisions of which are long, narrow, and undivided, on each side of it a long narrow club-shaped but almost straight-sided undivided saddle, a long narrow almost straight-sided unsymmetrically bifid lobe, a second saddle similar to the first, a second lateral bifid (irregularly trifid in some cases where the ventral point is asymmetrically subdivided) lobe similar to the first, a third saddle and a third lobe similar to the preceding ones (but the lobe is regularly bifid and slightly curved), a broad short (broader than long) rounded undivided U-shaped saddle, a short pointed funnel-shaped undivided lobe, and a short broad depressed, U-shaped saddle on the umbilical seam. All of the lobes and saddles decrease in size progressively toward the umbilicus. The writer has not been able to study sutures successfully on specimens with a diameter of less than 4 mm., and the sutures of specimens of that diameter are essentially like those of mature forms.

Remarks. Böse based his description of this species on a single specimen which he found on the Hargis Ranch near Marathon, Texas, "loose on rocks of shale of the Pennsylvanian age, near the boundary

line with the lower Permo-Carboniferous," but as the specimen was preserved in limonite and no more limonite fossils were found in the Pennsylvanian, he concluded that it had "rolled down from the Permian which probably belongs in the Hess formation." The Hargis Ranch is only 3 miles northeast of the locality where the numerous specimens studied by the writer were collected, and it is very probable that Böse's specimen came from approximately the same horizon, i. e., the upper part of the Gaptank formation. Böse was not able to study the internal sutures of his specimen, but the external features of it agree precisely with those of the writer's specimens.

The nature of the serration of the lobes serves to distinguish this form from most other similar species. However, Heilprin[31] has described as "*Ammonites*" *parkeri* a single fragmentary specimen from one of the Carboniferous horizons exposed near the border of Wise County, Texas, that has sutures that are strikingly similar to those of the species under consideration. Heilprin, in describing his specimen, states that the "umbilical region cannot be clearly made out," and in his diagrammatic representation of the sutures he shows definitely only a divided ventral lobe followed on each side by an external saddle and two lateral lobes and saddles. Both Smith[32] and Böse have therefore assumed that the first auxiliary lobe of his specimen was on the umbilical shoulder. However, Heilprin's sketches seem to the writer to indicate that there was a space between the part of the suture that he was able to study and the umbilical shoulder. If such is the case, then it is very probable that "*Ammonites*" *parkeri* Heilprin and *Marathonites hargisi* Böse are conspecific. This uncertainty will be removed only when more and better specimens have been found in the Carboniferous of central Texas.

Karpinsky[33] has described a fragmentary specimen from the Artinsk of the southern Urals as "*Popanoceras* sp. indet. (aff. *Parkeri* Heilprin)" that is very similar to the above described species. However, in that specimen the dorsal serrations of the branches of the ventral lobes are longer than the ventral, and Karpinsky states that the first auxiliary lobe, which apparently he was not able to see clearly, appears to be similar to the second lateral lobe, i. e., trifid.

[31]Heilprin, A., On a Carboniferous ammonite from Texas: Acad. Nat. Sci. Phila., Proc., pp. 53-55, text figs. 1 and 2, 1884.

[32]Smith, J. P., The Carboniferous ammonoids of America: U. S. Geol. Survey Mon. 42, p. 133, 1903.

[33]Karpinsky, A., *Op. cit.*, pp. 75-76, pl. 5, figs. 5 a-c, 1889.

Occurrence. Abundant in upper part of Gaptank formation, 4.5 miles S. 15° E. of Lenox, Marathon Basin, Brewster County, Texas; ½ mile north of preceding locality, i. e., at east end of Novaculite Hills and just below the overthrust; and probably from the same horizon on an anticline on the Hargis Ranch near milepost 580 of the Southern Pacific Railway, about 3 miles west of Marathon, Texas.

Collection. Peabody Museum of Natural History, Yale University, 12938 and 12941 (specimens from 4.5 miles of Lenox), and 12939 (specimens from Novaculite Hills).

PALEONTOLOGICAL NOTES

REMAINS OF HOLOTHUROIDEA FROM THE CARBONIFEROUS OF KANSAS

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I am indebted to Miss Betty Kellett for the opportunity to study the interesting fossils noted below. They were found at three localities as follows:

A. Near bridge just east of Elmdale, Kansas, on U. S. Highway 50 S, limestone in Elmdale shale upper Wabaunsee formation, upper Pennsylvanian (Carboniferous. Betty Kellett Locality No. 60; 9 specimens.

B. Four miles north of Burlingame, Kansas, on U. S. Highway 50 N. Burlingame limestone, lower Wabaunsee formation, Pennsylvanian (Carboniferous). Betty Kellett Locality No. 71 B; 12 specimens.

C. Near Cottonwood Falls, Kansas, just north of District School No. 17. Wreford limestone, lower Chase formation, lower Permian. Betty Kellett Locality No. 57; 3 specimens.

The fossils are minute calcareous plates which have grown in the integument of Holothuroidea (sea cucumbers). Considerable difficulty is experienced in properly placing such objects in the scheme of classification of the group because the modern arrangement is based upon living animals. However, these fossils appear more like certain wheel plates which have been described from members of the abyssal family, Elpidiidae than any other which has been found described. For purposes of indexing and reference it seems best that they be provided with a name.

LAETMOPHASMA (?) KANSASENSIS HANNA, N. SP.

Plate 40, figures 1-7

Wheel plates circular, slightly convex with a faint marginal rim and slightly scalloped around the circumference; immediately within the marginal ring there is a zone of large pores varying in number from eight to ten in the syntypes figured; central area marked with four or five additional pores, similar in size to the outer ones, or very much smaller.

Syntypes: 7 specimens from near bridge, just east of Elmdale, Kansas; upper Pennsylvanian (see loc. A. above).

Considerable variation is shown among the syntypes and when the series from the other two localities is examined there is found to be slightly greater differences in minor details but nothing of apparent importance is observed.

MEASUREMENTS (FILAR MICROMETER)

Diameter	*Locality*	
.3688 mm.	A Syntype 1	
.3808	A Syntype 2	
.2888	A Syntype 3	
.3300	A Syntype 4	
.3440	A Syntype 5	
.3400	A Syntype 6	
.3200	A Syntype 7	
.3280	B	Last four on upper row of slide
.4220	B	
.3290	B	
.5148	B	
.3600	B	Last three on second row of slide
.4060	B	
.3900	B	
.2628	C	
.2800	C	
.2488	C	

The three Permian specimens are definitely smaller than the others and probably belong to a different species but the preservation of the material scarcely warrants an additional name at this time.

The genus *Laetmophasma* was described by Ludwig[1] from specimens dredged between Lat. 16° 3′ N., and 27° 34′ N., and Long. 99° 52′ W., and 110° 53′ W., off the coast of Central America in 660 to 905 fathoms; temp. 2.90° to 3.9° C. The plates he illustrated are more like those here described than any found after a careful search of the literature.

Fossil plates and spicules belonging to Holothuroidea have been noted in the literature many times but they have usually been referred to shallower water families and genera, *Chiridota* in particular. Thus those found by Spandel[2] in the Zechstein (Permo-Carboniferous) of Germany were all placed in *Chiridota* and *Prosynapta*. Likewise, Schlumberger[3] referred those of the Eocene and Cretaceous of France to *Synapta*, *Chiridota*, *Thêelia* and *Priscopedatus*. The plates illustrated by these authors differ considerably from those from the Kansas limestones.

Later, Walcott[4] described four impressions of soft bodied animals from the Cambrian shales of Canada which he referred to the Holothuroidea but H. L. Clark[5] has cast some doubt on the classification. Dr. Clark stated that the oldest undoubted remains of this class of animals were from the Carboniferous.

The material described herewith has been deposited in the University of Kansas.

[1]Mem. Mus. Comp. Zool. Harvard Coll., vol. 17, no. 3, 1894, pp. 85-95, pl. 10, figs. 3-14, pl. 11, figs. 1-3.

[2]Abb. Ges. Nat. Hist. Nurnberg, vol. 11, 1898, pp. 40-45, pl. 13, figs. 9, 10.

[3]Note sur les Holothuridées du Calcaire grossier. Bull. Geol. Soc. France, Ser. 3, 1888, vol. 16, no. 6, pp. 437-441, 11 text figs.; and vol. 18, 1890, no. 3, pp. 191-205, 43 figs.

[4]Middle Cambrian Holothurians and Medusae. Smith. Misc. Coll., vol. 57, no. 3, 1911, pp. 42-68, pls. 8-13, 6 text figs.

[5]Science, n. s., vol. 35, 1912, pp. 274-278.

A NEW GENUS OF SILICOFLAGELLATA FROM THE MIOCENE OF LOWER CALIFORNIA

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Several years ago Mr. Carl Beal directed extensive geological investigations in Lower California for the Marland (now Continental) Oil Comapny. While exploring in the central southern part of the peninsula the party collected a sample of organic shale near the settlement of Purissima. This sample eventually came into possession of Stanford University and a portion of it was sent to the California Academy of Sciences by exchange through the kindness of Dr. Hubert G. Schenck.

The sample consists largely of fossil diatoms and was prepared for study for that reason. However, there are numerous radiolaria, silicoflagellata and sponge spicules, all silica-forming organisms. No calcareous forms are present. The shale is light in weight, light brown in color and resembles many of the California siliceous shales, physically. Among the many interesting forms present, one which I take to be a peculiar silicoflagellate is abundant and may be described as follows:

ROCELLA HANNA, N. G.

An almost flat, circular, disk, composed of silica and variously marked with large and small openings; genoholotype; *Rocella gemma* Hanna, n. sp. The genus is placed in the Silicoflagellata, a group of marine Protozoa.

ROCELLA GEMMA HANNA, N. SP.

Plate 40A, figures 8-18

Disk circular, almost flat, with a zone of small pores around the margin, succeeded inwardly by much larger openings; central area marked with one or two distinct beads.

Diameters of figured specimens	(*Filar Micrometer*)
8—.10 mm. Holotype	13—.0508 mm.
9—.052	14—.0526
10—.051	15—.0470
11—.060	16—.050
12—.049	17—.0484
	18—.0262

Holotype: No. 3258; paratypes: Nos. 3259-3268, 11 specimens from Loc. 1051 (C. A. S.) San Gregorio Ranch near Purissima, Lower California; San Gregorio formation, Miocene; C. R. Schwarts, Coll., 1920.

When a study of these objects was first begun it was supposed that they were wheel-plates of Holothuroidea similar to those described in the preceding paper but there are several reasons for including them in the Silicoflagellata. In the first place no record of any member of the Holothuroidea has been found

which has siliceous bodies in the integument. Moreover, the only organisms known to have used silica exclusively in the building of their skeletons are the radiolarians, sponges and silicoflagellates among the animals and diatoms among the plants. A review of much literature on recent deposits formed on the bottoms of the oceans has disclosed no group to which a siliceous form could be referred, other than those enumerated.

Of these groups, the fossils here described are definitely excluded from the diatoms by the presence of large openings or pores. Also, they cannot be conveniently placed in Radiolaria because of the absence of the symmetry so well known in that group and the objects are obviously not remains of sponges. They fall readily into the Silicoflagellata although they differ radically from all other genera of the group. Still they might be considered a *Mesocena* which has developed a network over the circular hoop. In view of the perfection of the preservation and the abundance of the fossils there is the admitted possibility that they may have been previously detected and described in some publication which has not been found.

Consideration has been given to the possibility that the objects were originally calcite, (such as wheels of Holothuroidea), and that this material has been replaced by amorphous silica. There is very little possibility of this being the case because there is no other corroborative evidence in the shale to indicate that there has been any such replacement. Silica is known to have replaced cellulose in petrifaction of wood and there preserved most of the minute details but I have not seen a case of its having replaced calcite with such great perfection as would have been necessary as in the case of these minute and delicate objects.

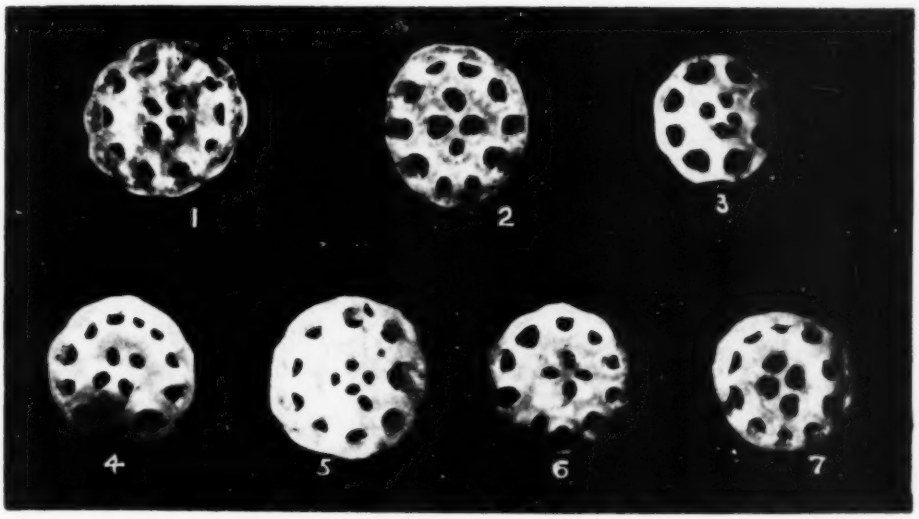
The sample from which these fossils were selected is believed to have come from the Miocene. Heim referred to the similarity of the shale to the Monterey formation of California but did not have direct paleontologic evidence for support. The diatoms and other silicoflagellates present show definitely that the age is not typical Monterey; it is close to some parts of the Temblor of California and the Calvert formation of eastern America and it is believed to be equivalent to some portion of the Helvetion stage of the European time scale.

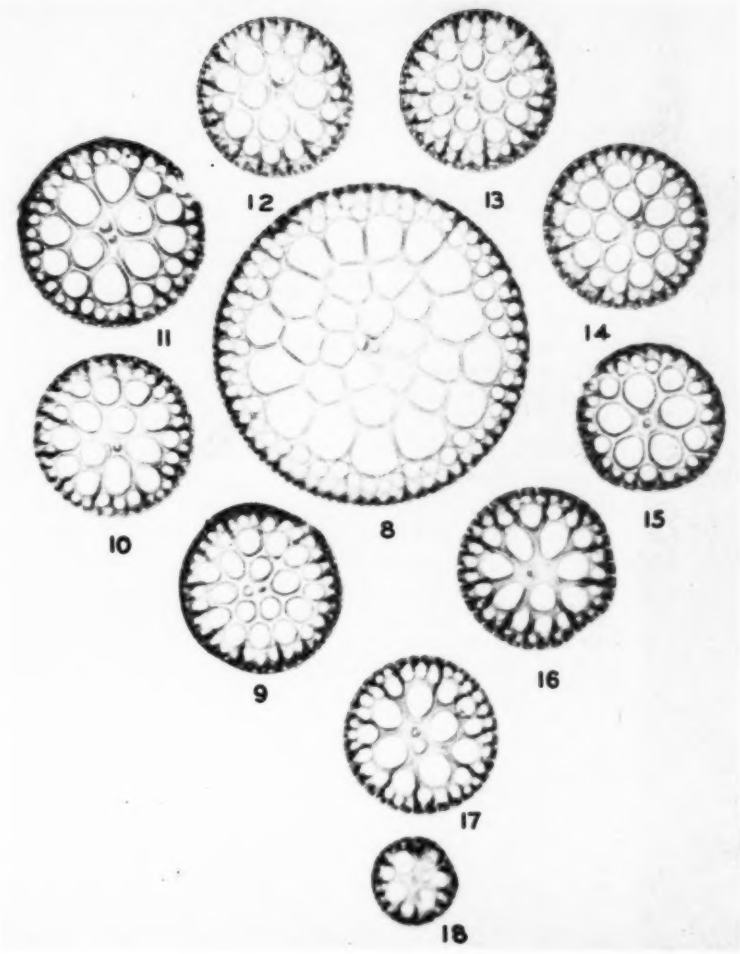
An excellent review of the literature bearing upon the Miocene of Lower California and this deposit in particular may be found in a paper on the Paleontology of the region by L. G. Hertlein and E. K. Jordan, (Proc. Calif. Acad. Sci., ser. 4, vol. 16, no. 19., pp. 605-647, pls. 17-21, 1927.)

EXPLANATION OF PLATE 40

FIGS. 1-7.—*Laetmophasma (?) kansasensis* Hanna, n. sp. Syntypes from near Elmdale, Kansas, limestone in Elmdale shale, upper Wabaunsee formation (upper Pennsylvanian). Enlarged approximately 60 diameters; see text for actual dimensions of objects.

8-18.—*Rocella gemma* Hanna, n. g., n. sp. Fig. 8 is the holotype, No. 3258 (C. A. S.); from San Gregorio Ranch, near Purissima, Lower California; San Gregorio formation, Miocene. All figures enlarged approximately 420 diameters; see text for actual dimensions.





UNIV. OF MICH.

THE OSTRACODE GENUS *HOLLINELLA*

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Paleontologists seldom know as much as they should of the living representatives of their fossils. Zoologists, on the other hand, seldom have more than a superficial acquaintance with the life of the past. This is unfortunate, but is a more or less inevitable consequence of specialization. There is a real need for coöperation between workers in the two fields and this need is felt so keenly that hasty and ill-considered comments of a zoologist on paleontological matters may be given more weight by paleontologists than they merit. This is my excuse for this note.

C. H. Blake, a worker in the field of living ostracodes, in a recent note[1] offers criticism of a paper by Kellett[2] dealing with the genus *Hollinella*. Kellett's main thesis is that certain frilled Pennsylvanian forms previously referred to *Hollina* are, in fact, conspecific with certain frilless forms that had been set apart under the name *Hollinella* only a short time before. Her evidence, briefly, is that at several horizons three types of hollinids are found associated together, one without a frill (*Hollinella* as formerly understood), a second with a narrow frill and a third with a wide frill. These latter two were referable to *Hollina* as then generally understood. These three types appear at different horizons but in each case with some changes of characters that are regarded as of specific value. The remarkable fact is that these changes appear to be synchronized in all their details in each of the three types. The conclusion is unavoidable that the three forms do not represent three species belonging to two genera but mark a single trimorphic species at each horizon. To explain this trimorphism Kellett suggests that the frilless forms are the young of both sexes and the mature males, the narrow-frilled forms non-breeding females and the wide-frilled forms breeding females. It was pointed out that what appears to be sexual dimorphism is a characteristic of the Beyrichiidae of which the hollinids are members and it was suggested that the space between the wide frill of the supposed breeding females might have served as a place for the protection of the broods of young. Other arguments tending to support the suggestion of sexual trimorphism were presented.

Kellett's conclusion that the three types are conspecific in no way rests upon the suggestion of sexual trimorphism, nor on the more or less well taken points in support of that suggestion. It rests entirely on the obsrved fact that specific differences appear synchronously several times in all three types. Blake seems to have entirely missed this very essential point. It appears to me that Kellett sets forth the evidence for this as well as could be expected considering the limitations of a short paper with few plates. The final appeal as regards the characters of these fossils is to her collections which I have seen while Blake has not. I am in entire agreement that the three forms at each

[1]This journal, Vol. 4, no. 3, Sept., 1930, pp. 297-298.

[2]This journal, Vol. 3, no. 2, June, 1929, pp. 196-217.

horizon grouped together by Kellett are conspecific. Any other conclusion would be asking parallelism to perform miracles that are far more incredible than that the Paleozoic marine Berichiidae may have differed considerably in the details of their life histories from the recent, largely fresh-water, Podocopa.

Blake's criticism of the details of Kellett's suggestion that the three forms of each species represent trimorphs have slightly more weight although most of them are based on the fixed concept that the Beyrichiacea, the most isolated superfamily of fossil ostracodes, must not have departed in any detail of their life histories from what is found today in not very closely related stocks. Such a position is untenable. Granting what seemingly must be granted, that the three types are conspecific, what suggestion more plausible than Kellett's can be made to explain such trimorphism? It is here that a student of living forms, with eyes and mind open, could perhaps offer suggestions of constructive value. The suggestion made by Kellett seems to fit the observed facts. Paleontologists will welcome any suggestion that fits them better.

The distinction between the genera *Hollina* and *Hollinella* as emended by Kellett rests chiefly on hinge structure and to a lesser degree on the noding and the form of the frill. It seems clear that the hinge structure described for *Hollinella* is lacking in *Hollina insolens* (Ulrich), the genotype of *Hollina*. Granting sufficiently preserved and typical specimens (and the holotype was one of them), and granting accuracy of observation, the distinctions drawn seem perfectly valid.

In conclusion, it appears that much of Blake's criticism of Kellett's paper and in particular his conclusions are, to use his own words, "if not entirely absurd,—so highly improbable as to be, at present, quite unacceptable."

THE "GUAYABAL" FORMATION OF MEXICO

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In W. L. F. Nuttall's excellent paper[1] on the principal index foraminifera of the Eocene series of Mexico, the author draws certain conclusions in regard to nomenclature which I feel are open to criticism. Discussing the "Guayabal" formation of Middle Eocene age, he says,[2]

> The term Tempoal was introduced by W. A. Ver Wiebe for shale exposed in the river at the town of Tempoal. Cole pointed out that the foraminiferal fauna of the Tempoal is very similar to that of the Guayabal. The writer has also examined material from this locality and regards the type Tempoal as constituting probably the lower part of the Guayabal. There appears to be no reliable lithological or paleontological means by which it is possible to separate the type locality Tempoal from the Guayabal, so that the former name appears superfluous.

[1]W. L. F. Nuttall, "Eocene Foraminifera from Mexico," Jour. Pal., Vol. 4 (1930), pp. 271-293.

[2]Idem., p. 275.

I know of no published reference to the "Guayabal" formation previous to 1927, when W. S. Cole proposed that name in describing numerous species of foraminifera from Mexican deposits of Middle Eocene age.[3] He restricted the term Tempoal to the lower 500 feet of the Middle Eocene section and proposed the name Guayabal for the upper 1,000 feet, his thickness being derived from studies of Mexican South Field well samples. His divisions were based chiefly on rather minor faunal differences between the two parts of the section. Prior to publication, Mr. Cole kindly sent me a copy of the manuscript of his paper, at which time I offered the criticism that his distinction between parts of the Middle Eocene in the region he discussed were not of formational rank. I, therefore, urged him to omit the name Guayabal and adhere to the use of the term Tempoal for the entire Middle Eocene section, inasmuch as the latter was well established in the literature.

I am glad to observe that Nuttall considers the type Tempoal and type "Guayabal" exposures as representing merely different horizons in the same formation. Having personally visited and examined material from both localities, I am in full agreement with this view. The lithologic similarity of the two outcrops is particularly striking. A study of South Field well sections, also, leads to the conviction that the beds under discussion constitute a lithologic entity. The term Guayabal seems to be a sort of private designation used by the geologists of the Aguila Petroleum Company in Tampico, who evidently failed to recognize that they were dealing with the upper part of the Tempoal formation.

Dr. Nuttall, however, is obviously in error in stating that the name Tempoal is superfluous. Since Ver Wiebe[4] established that name and designated a suitable type locality of exposure some time before the term Guayabal was introduced in the literature, it is clear that recognized rules of nomenclature dictate the acceptance of Ver Wiebe's name. Hence, the name Guayabal is superfluous.

MYTILUS LOELI, A NEW NAME FOR *MYTILUS KEWI* WIEDEY (NOT *MYTILUS KEWI* NOMLAND)

U. S. GRANT, IV
San Diego Academy of Science, San Diego, California

In a recent number of the Journal of Paleontology L. W. Wiedey[1] described a *Mytilus kewi* from the Vaqueros formation, lower Miocene of California. Unfortunately this same name had been used by Nomland[2] in 1916 for a quite

[3]W. S. Cole, "A Foraminiferal Fauna from the Guayabal Formation in Mexico," Bull. Am. Pal., Vol. 14 (1927), No. 51.

[4]Am. Jour. Sci. (5), Vol. 8 (1924), p. 486.

[1]Vol. 3, No. 3, p. 281, pl. 31, fig. 2, September, 1929.

[2]Univ. Calif. Publ. Geol., Vol. 9, p. 206, pl. 9, fig. 1, 1916.

different upper Miocene and lower Pliocene species of the Coalinga region, San Joaquin Valley. I therefore propose the new name *Mytilus loeli*[3] as a substitute for Wiedey's homonym.

Mytilus loeli Grant, n. n., is a broad, strongly arcuate species which may be related to *M.* (*Mytiloconcha*) *coalingensis* Arnold, a larger, less arcuate species of the lower Pliocene. The latter belongs to the group with the umbo internally greatly thickened. The hinge characters of Wiedey's renamed species is as yet unknown and it may prove to be subgenerically different from Arnold's species.

[3]Named for Mr. Wayne Loel of Los Angeles, California, an authority on the lower Miocene of California.

REVIEWS AND NEW PUBLICATIONS

ROIG, MARIO SANCHEZ, Revision de los Equinidos Cubanas. Mem. de Soc. Cubana de Historia Natural-Felipe Poey, Vol. 6, Habana, 1924.

This paper consists of what appear to be two oral progress reports to the society. Numerous species listed as new are not described. Noteworthy are the removal of *Macropneustes cubensis* Cotteau to *Mauritanaster* Lambert, *Asterostoma castroi* Egozcue to *Antillaster* Lambert, *Breynia cubensis* Cotteau to *Brissoides* Klein; the description of two new genera, *Habanaster* and *Sanchezaster* by Lambert. The plates of this paper are included in the following more comprehensive contribution.

M. C. Israelsky

ROIG, MARIO SANCHEZ. Contribucion a la Paleontologia Cubana—Los Echinodermos de Cuba. Bol. de Minas, Num. 10, Havana, Dec. 1926.

According to Roig one hundred species of echinoids, two asteroids, and two crinoids are described from the Cretaceous and Cenozoic of Cuba. Don Aurelien Vallette of Paris is responsible for the asteroid and crinoid descriptions; the echinoids being described by both Roig and Lambert. A bibliography and forty-three halftone plates accompany the paper. This paper should be very useful to students of the paleontology and stratigraphy of the Gulf Embayment.

M. C. Israelsky

JEANNET, ALPH. Contribution a l'Etude des Echinides tertiares de la Trinité et du Venezuela. Mem. Soc. Paléon. Suisse, Vol. 48, 1928.

In this excellent contribution seventeen species are described as new, five are referred to previously described species, fourteen are considered specifically indeterminate. The species are from the upper Eocene, the lower and middle Miocene. The paper is illustrated with six photogravure plates and twelve text figures.

M. C. Israelsky

SOCIETY RECORDS AND ACTIVITIES

PACIFIC SECTION OF THE SOCIETY OF ECONOMIC PALEONTOLOGISTS AND MINERALOGISTS

The activities of the Pacific Section of the Society of Economic Paleontologists and Mineralogists have been initiated by Mr. D. D. Hughes Chairman-elect. Mr. Wissler and Dr. Hanna have each presented instructive papers, following the previous plan of studying vital sections on the Pacific Coast.

The following is the tentative program of the Pacific Section of the Society of Economic Paleontologists and Mineralogists for the year 1930-1931. Any one interested in this work is cordially invited to attend the meetings held at the Engineers Club, 833 South Spring Street, Los Angeles, California, at 6:30 P. M.

September 4, 1930	Wissler and Hutchinson: Puente Hills Section
October 2, 1930	Hanna and Church: Sections across the Kreyenhagen (Lillis) Shale
November 6, 1930	K. E. Lohman: A Diatom Paper
December 4, 1930	R. E. Stewart: Wildcat Section
January 1, 1931	Goudkoff and Hughes: Chico-Martinez Creek Section
February 5, 1931	A. R. May: Carneros Creek Section
March 5, 1931	Tieje and Doane: Eaton Canyon Section
April 2, 1931	W. D. Rankin: Reliz Canyon Section
May 7, 1931	H. L. Driver: Los Angeles City Section

522 Standard Oil Bldg. W. H. HOLMAN, *Secretary*

NEW MEMBERS

The Secretary of the Society, Dr. Gayle Scott, reports the election of seventeen new members since publication in March, 1930, of the last membership list. In addition there are twelve pending applications. The list is as follows.

John Emery Adams, Box 578, Midland, Texas
Bell, Frank W., 2024 "C" Street, Bakersfield, California
Bingman, Neal J., c-o California Company, Box 578, Midland, Texas
Burckhardt, Dr. Carlos, General Leon 60, Tacubaya, Mexico, D. F. (Honorary)
Cahill, Edgar D., Skelly Oil Co., 510 Ellis-Singleton Bldg., Wichita, Kansas
Canfield, Charles R., 1925 W. 43rd St., Los Angeles, California
*Eifler, Gus K., 4008 Avenue "F," Austin, Texas
Gravell, Donald W., 1901 Huldy St., Houston, Texas
Gordon, Wallace, 1130 Milam Bldg., San Antonio, Texas
Haight, Harold Warren, McAllen, Texas

*Howell, B. F., Department of Geology, Princeton University, Princeton, New Jersey
Kemp, Augusta Hasslock (Mrs.), Seymour Public Schools, Seymour, Texas
*Moss, R. G., Department of Geology, University of Kansas, Lawrence, Kansas
Nomland, J. O., Standard Oil Co. of Calif., Standard Oil Bldg., San Francisco, California
*Sample, Charles Hurst, Edna, Texas
Smith, James Perrin, Leland Stanford University, Leland Stanford, California (Honorary)
Upp, Jerry E., Box 2007, Tulsa, Oklahoma

APPLICANTS

Benedum, Darwin Marx, 414 West Elsmere Place, San Antonio, Texas
*Broughton, Martin N., 2204 Nueces St., Austin, Texas
Dallmus, Karl Fred, c–o Transcontinental Petr. Co., Apt. 657, Tampico, Tamps., Mexico
*Ferguson, Glenn Chas., Rm. 604 Beaux Arts Bldg., 1709 W. 8th St., Los Angeles, California
Hammill, Chester Armstrong, 1417 First Nat. Bank Bldg., Dallas, Texas
Milner, H. B., Imperial College of Science and Technology, London, England
Moyer, Dorothy A., 368 S. Catalina, Pasadena, California
*Palmer, Dorothy Kemper, Hotel Sagua, Sagua La Grande, Cuba
Weaver, Charles E., Dept. Geol., Univ. of Washington, Seattle, Washington
Atchison, James W., Box 96, Pure Oil Company, Grand Saline, Texas
Spencer, Maria, Superior Oil Co., San Angelo, Texas
Morrow, A. Lyndon, 933 Rhode Island St., Lawrence, Kansas

*Associate members.

NOTES ON THE FALL MEETING OF THE SOCIETY OF ECONOMIC PALEONTOLOGISTS AND MINERALOGISTS AT ARDMORE AND ADA, OKLAHOMA OCTOBER 25 AND 26, 1930

The fourth annual fall field meeting of the Society of Economic Paleontologists and Mineralogists was held in southern Oklahoma around Ardmore and Ada, October 25 and 26. Clear, crisp autumn weather greeted a large group of paleontologists from the Mid-Continent, Southwestern and Gulf Coastal Plains areas.

Under the able direction and chairmanship of C. E. Decker, Professor of Paleontology at the University of Oklahoma, the trips were among the best organized and most interesting that the Society has had. The itinerary for the Ardmore region was prepared by C. W. Tomlinson, Maynard White and other Ardmore geologists, and the excursions were conducted by them. The Ada itinerary was prepared by John Fitts and Rex McGehee. The Oklahoma Geological Survey, under the direction of C. N. Gould, assisted in printing the maps and in assembling and duplicating material.

The group assembled at the Ardmore Hotel Friday evening, October 24. C. W. Tomlinson gave a talk on the stratigraphy and structure of the Ardmore Basin and illustrated his talk with lantern slides and cross-sections. Maynard White gave a paper on the distribution of the micro-faunas. Hugh D. Miser spoke briefly on the wider correlation of the Pennsylvanian formations, and C. N. Gould made suggestions relative to field trips.

The following day, Saturday, October 25, the paleontologists under the leadership of C. W. Tomlinson and Maynard White, visited the richly fossiliferous Pennsylvanian and older formations in the Ardmore Basin and Criner Hills.

The Ardmore Basin excursion ended about 5 P. M. The paleontologists later assembled at the Aldridge Hotel, Ada, for dinner, after which there was a program. John Fitts spoke briefly on the geology around Ada and explained plans for the trip in that region. Robert Whiteside described the various Pennsylvanian formations around Ada, noting the chief points of interest in the micro-fauna of each. E. H. Sellards and F. B. Plummer spoke on the correlation of the Pennsylvanian of Oklahoma and Texas. Hugh D. Miser gave an illuminating talk on the relation of the Caney shale in Johns Valley of the Ouachita Mountains to the outcrops of that formation elsewhere, particularly in the Arbuckle Mountain region. C. L. Cooper spoke briefly on the characteristics and distribution of the Sycamore limestone.

The following day, October 26, micro-faunal samples, and large fossils were collected from more than thirty of the best and most fossiliferous Pennsylvanian horizons in the region. Brief discussions, led by John Fitts, were held in the field.

The itineraries for both days contained unusually interesting descriptive matter and maps. Both were bound together in a convenient and attractive folder. A few of these may still be obtained from the Oklahoma Geological Survey at fifty cents per copy.

GAYLE SCOTT, *Secretary*

AMONG PALEONTOLOGISTS

HOLLIS D. HEDBERG, in charge of the geological laboratory of the Venezuelan Gulf Oil Company, has recently returned to Maracaibo after a two months vacation in the United States.

PAUL D. GOUDKOFF has been working for the past several months on a series of samples collected by Dr. O. P. Jenkins from the Kreyenhagen shale and the Eocene beds developed in the Coalinga district and on the west side of the San Joaquin valley, California.

M. C. ISRAELSKY, paleontologist for the United Gas Corporation, has recently been transferred to Houston, Texas. His address is post-office Box 1760.

G. DALLAS HANNA has completed a series of dredgings in Monterey Bay and near Santa Catalina Island, California, in water up to 100 fathoms in depth, in order to procure living foraminifera, diatoms, mollusca, etc., for comparison with fossil material from western North America.

JOHN R. SANDIDGE, professor in the Department of Geology, Princeton University, is engaged in a study of macroscopic and microscopic fossils from Angola, Portuguese West Africa.

JEROME S. SMISER, who was awarded a Storrow fellowship for the academic year 1930-31, will continue, under direction of Prof. J. R. Sandidge at Princeton University, study of the microscopic parts of fossil ecninoids which was begun at Texas Christian University. This will be the subject of a dissertation for the doctorate.

J. HARLAN JOHNSON spent the summer in a study of the stratigraphy and paleontology of Pennsylvanian beds in central Colorado for the United States Geological Survey.

HAROLD HAWKINS assisted Dr. W. H. Schoewe of the University of Kansas during the summer in a study of the geology of part of northeastern Kansas for the Kansas Geological Survey.

ABRAM O. THOMAS, professor of paleontology at the University of Iowa, is suffering from a severe illness which has prevented him from continuing his teaching work this autumn.

ROBERT L. RIGGS, chief geologist of the Indian Territory Illuminating Oil Company spent part of the summer in Colorado.

JOHN B. REESIDE, JR., of the United States Geological Survey has been engaged during autumn months in field studies near Glenwood Springs, Colorado.

JAMES S. WILLIAMS of the United States Geological Survey spent the summer field season visiting Carboniferous areas in the western United States, in company with John B. Reeside, Jr., and part of the time with Hugh D. Miser.

GAYLE SCOTT of Texas Christian University and FREDERICK B. PLUMMER of the University of Texas have nearly completed an important monograph of Pennsylvanian ammonoids of Texas. The work will contain about 300 pages of text and about 30 plates.

RAYMOND C. MOORE, of the University of Kansas, addressed the Science Seminar of Texas Agricultural & Mechanical College, November 3, on exploration of the Grand Canyon. While in Texas Mr. Moore also lectured before the Southwestern Geological Society, the University of Texas Science Club and at Baylor University.

DAVID M. DELO is an assistant instructor in the Department of Geology, Northwestern University during the present academic year.

RYCROFT G. MOSS, of the Department of Geology, University of Kansas, is preparing maps and a geological report on Ness and Hodgeman counties, western Kansas. This area contains exposures of Cretaceous and Tertiary rocks.

JOHN R. BALL, associate professor of geology and paleontology at Northwestern University attended the field conference of the Kansas Geological Society in Colorado and New Mexico, September 1-6, 1930. FANNIE C. EDSON, BRUCE H. HARLTON, J. HARLAN JOHNSON, I. A. KEYTE, A. W. MCCOY, RAYMOND C. MOORE, JOHN B. REESIDE, JR., ROBERT L. RIGGS, CHARLES RYNIKER, E. H. SELLARDS, and ALLEN C. TESTER, are other members of the Society of Economic Paleontologists and Mineralogists who took part in this excellently planned and directed field excursion.

BRUCE L. CLARK, of the University of California, Berkeley, has recently issued a volume on the stratigraphy and faunal horizons of the Coast Ranges of California, illustrated by 50 plates of index fossils.

STEPHEN ROOK and MERLE C. ISRAELSKY led the Eighth Annual Field Trip of the Shreveport Geological Society, June 14th and 15th, over the Upper and Lower Cretaceous section of southwestern Arkansas.

HANS E. THALMAN, whose address is Apartado 86, Puerto Mexico, Vera Cruz, Mexico, is reviewing the *Journal of Paleontology* for the *Geologisches Zentralblatt* published by Dr. K. Keilhack in Berlin. Other papers published by members of the Society will be welcomed by Mr. Thalman for writing of reviews.

A large quantity of well samples from the Seminole district in central Oklahoma is being made available to institutions at cost of transportation. Wells in this region penetrate varying thicknesses of Pennsylvanian, Mississippian, Devonian, Silurian, and Ordovician rocks. Such material is, of course,

very useful for training of students in subsurface geology and paleontology. Limitation of storage space requires that these samples be moved very soon and those not sent out for scientific or educational uses will be thrown away. The opportunity to secure this valuable material is offered through courtesy of the Gypsy Oil Co., and those interested in it should write to Mr. J. T. Richards, Gypsy Oil Co., Oklahoma City, Okla.

THE JAMES HALL GEOLOGICAL LIBRARY, consisting of many rare reprints and numerous volumes of the early New York State Museum Reports as well as the Natural History and Paleontologic Reports of New York, which was acquired by the Walker Museum at the University of Chicago when it purchased the Hall Paleontologic Collection, is being disposed of either for cash or paleontologic exchange. Additional information may be obtained from Dr. Carey Croneis, Department of Geology, Walker Museum, University of Chicago.

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